MACHINERY.

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EPICYCLIC GEARING.—1.

ITS PRINCIPLES OF OPERATION AND ITS APPLICATION IN MACHINE DESIGN.

The term epicycle is derived from the Greek and means in its original sense a circle having its center moving along the circumference of another circle. The word originated in ancient astronomy, the supposition being that every planet moved in a small circle, or epicycle, the center of which was carried uniformly along the circumference of a large circle or deferent. The term epicyclic, as applied to gearing, signifies that the motion of certain gears of the train corresponds to the motion of the epicycle, and while the term is of Greek origin and the principles of this form of gearing are about as clear to most mechanics and draftsmen as the classic language from which it derives its name, the subject will be found upon analysis to be a very simple one.

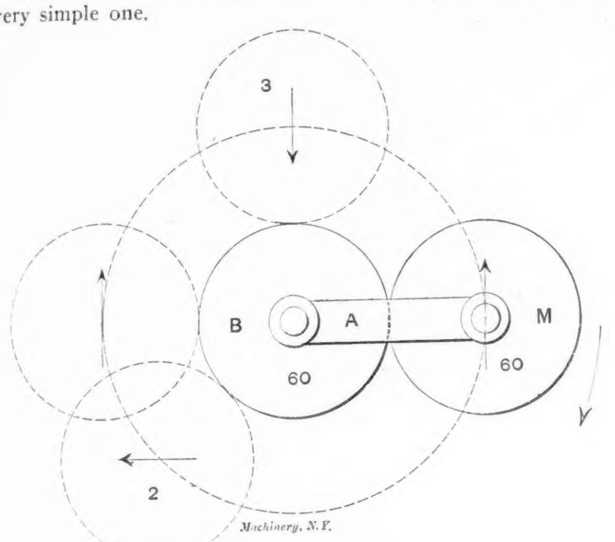


FIG. 1. TWO-WHEEL TRAIN.

In the treatment which follows no attempt has been made at originality. Several standard authors have presented the subject so clearly that it would be presumptuous to try to improve upon their work. The line of reasoning contained in Kennedy's "Mechanics of Machinery" has been followed in part and acknowledgement should be made to notes issued to his students by Prof. P. Schwamb, Boston Mass., for the method given of tabulating the successive movements of epicyclic trains. This method has been used by Prof. Schwamb for many years in the instruction of his classes and is original with him.

Gearing, as commonly arranged, is supported by a stationary framework. The first wheel of the train receives its motion from some outside source and imparts it to the other gears, all of which revolve. In an epicyclic gear train, however, one of the gears is either stationary or receives a motion independent of the others and the frame itself revolves about the axis of this gear, carrying with it the other wheels. The frame, of course, assumes the form of an arm and the gears which it carries have a combined motion of rotation, due to the contact of the gear-teeth; and of translation in the path of a circle, about the axis of the first gear, due to the rotation of the arm.

The problem is generally to find the number of turns made by the last gear of the train relative to the number of turns of the arm.

The simplest possible case is that of a two-wheel train shown in Fig. 1, where B is a fixed gear which does not revolve, and gear M is carried around this gear in the path of the dotted circle by the motion of the arm A, which connects the two gears.

In what follows right-hand rotation will be spoken of as positive and will be assumed to be in the direction in which the hands of a watch move when looking at the face of the watch. Left-hand rotation will be spoken of as negative and will be assumed to be in a direction opposite to right-hand motion.

Suppose the arm to make one complete right-hand turn as indicated by the arrow at the right (Fig. 1), and assume for the moment that the two gears and the arm A are locked together, gear B turning with the arm. Gear M will then have made one complete revolution, right-hand, simply through the motion of the arm and without any action of the wheel teeth. But the problem is, to find how many turns M would have made if B had been stationary instead of turning with the arm. If we hold the arm stationary and turn B back to its original position, the final effect upon M will be the same as though B had remained stationary in the first place. Turning B back one turn, will make M turn once in a right-hand direction, since both gears have the same number of teeth. The total number of rotations for M, therefore, for one turn of the arm, is two, in a right-hand direction

Call R the velocity ratio of the train. For our purpose velocity ratio may be defined as the number of turns made by the last gear for one turn of the first gear and it is to be obtained by dividing the product of the drivers by the product of the driven gears. The total number of revolutions made by M will be $1 + R$; and as R here $= 1$ we have $1 + R = +2$, the positive signs indicating right-hand rotation when the arm turns to the right. In Fig. 1, the position of gear M is indicated at different points by the dotted circles and the arrows.

Three-wheel Train.

In Fig. 3 is an example of a three-wheel train. Assume as before that the arm makes one turn, right-hand, carrying all the wheels with it. M will then make one turn right-hand as a re-

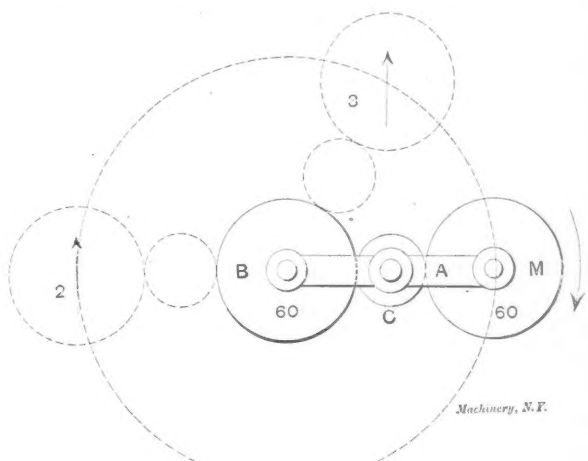


FIG. 2. THREE WHEEL TRAIN

sult of the motion of the arm. Now hold the arm stationary and turn back B to its original position and since there is an intermediate gear C in this train, M will turn once in a left-hand direction. B and M having the same number of teeth. The total number of revolutions of M, therefore, will be °, or it does not turn at all when the arm moves.

The total number of revolutions of M is indicated in this case by $1 - R$. If the velocity ratio of B and M be 1, then $1 - R =$ °. If B has 30 teeth and M has 60 the velocity ratio (ratio of driver to driven) would be $\frac{1}{2}$ and $1 - R = 1 - \frac{1}{2} = +\frac{1}{2}$. If the numbers of the teeth were reversed, $R = 2$ and $1 - R = -1$. Thus the motion of M is either positive or negative, for positive motion of the arm according as M has more or less teeth than B; while if it has the same number of teeth it will have no rotary motion, as indicated in the dotted positions in Fig. 2.

From these examples of the two and three-wheel trains, the following rule may be derived:

When the arm of an epicyclic train turns right-handed, the turns made by the last wheel for one turn of the arm are equal in number and direction to one plus the velocity ratio if the number of axes be even, and one minus the velocity ratio if the number of axes be odd. It is understood, of course, that the algebraic signs of the results are to be retained and that they indicate positive or negative rotation as explained above.

Tabulating the Results.

What is doubtless the most comprehensive method of treating epicyclic gearing is that of tabulating the results of the successive movements of the parts. For example, in Fig. 1 the train was locked and all the gears turned around once with the arm. Arrange columns for the arm, the first gear and the last gear, as

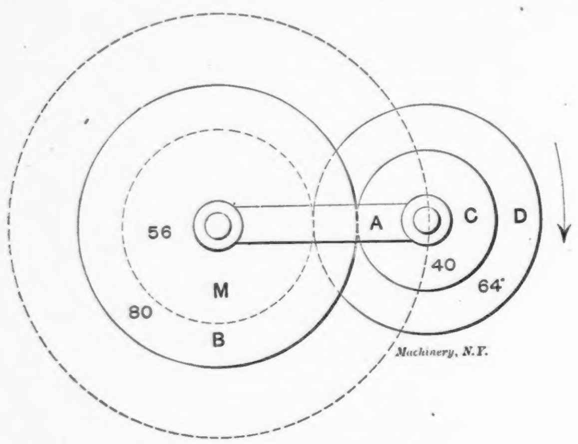


FIG. 3. FOUR-WHEEL TRAIN.

shown below, and in line with "train locked" write +1 under each of the headings to indicate the motion of the parts. Now we have done with the arm just what was desired, but the first gear has been turned when it should have remained stationary. So with the arm fixed turn back the first gear and the motions of the parts will be as indicated in the second row of figures. Summing the results, we have, arm turns once, right-handed; first gear, which in reality is stationary, makes no turns; and last gear makes two positive turns.

	Arm.	First Gear	Last Gear.
Train Locked...............	+1	+1	+1
Arm Fixed..................	0	—1	+1
	+1	0	+2

The table for the three-wheel train shown in Fig. 2 is as follows:

	Arm.	First Gear	Last Gear.
Train Locked...............	+1	+1	+1
Arm Fixed..................	0	—1	—1
	+1	0	0

Reverted Trains.

In Fig. 3 is an example of a four-wheel train in which the last wheel, M, is loose upon the axis about which the arm revolves. Such an arrangement is called a reverted train and by its use it is sometimes possible to obtain a velocity ratio between the first and last wheels that it would be difficult to obtain otherwise.

In this train the first gear, B, has 80 teeth, the second gear, C, has 40 teeth, the third gear D, which is attached to the same spindle as C and revolves with it has 64 teeth, and the last gear, M, which mates with D, has 56 teeth. Gear B is stationary and in order to find how many turns gear M makes for one turn of the arm in a right-hand direction, we must first find the velocity ratio of the train.

For the sake of clearness the same train of gears is shown in Fig. 4, except that gear M has a separate axis and the journals are supposed to turn in stationary bearings so that there is no epicyclic action. Assume B and D to be the drivers and C and M the driven wheels. The velocity ratio will then be

$$\frac{80 \times 64}{40 \times 56} = \frac{16}{7} = 2\frac{2}{7}, \text{ or}$$

every time B makes one turn M will make 2 2-7 turns. Having found the velocity ratio of the train, considered as a simple train of gears, we may return to Fig. 3, and apply the rule given above for epicyclic trains. The number of axes of the train is odd. That is, C and D must be counted as though on one axis, because they rotate together as one gear, and B and M, while nominally on one axis do not rotate together and it should be considered that each has a separate axis, making three axes in all. By the rule, one turn of the arm, right-handed, would cause M to turn 1 — R or —1 2-7 times.

If desired, the result may be tabulated thus:

	Arm.	First Gear.	Last Gear.
Train Locked...........	+1	+1	+1
Arm Fixed..............	0	—1	—2 2-7
	+1	0	—1 2-7

In an epicyclic train it is not necessary that the first gear should be stationary. It may have a motion of its own independent of the arm in either direction and an example of this arrangement is shown in Fig. 5. The arrangement and diameters of the gears are as in Fig. 3 and the velocity ratio of the first and last gears is the same as before. In this sketch, however, it is shown how the arm A may be driven by the shaft and pinion a,

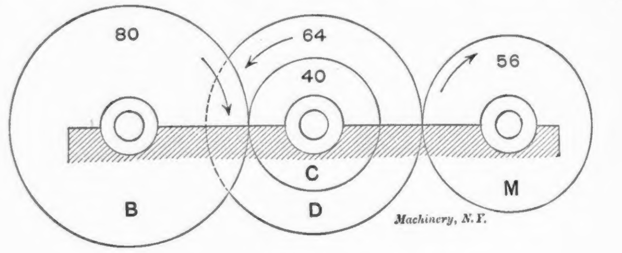


FIG. 4.

and if A and M be loose upon the main shaft, and B is keyed to it, the latter wheel may receive an independent motion through this shaft.

Example: Suppose that every time A makes five turns to the right, B makes one turn to the left. Find the number of turns made by M .

In the last example it was found that the last gear made —1 2-7 turns for each + turn of the arm. For five turns of the arm, therefore, the last gear would make 5 × —1 2-7 or —6 3-7

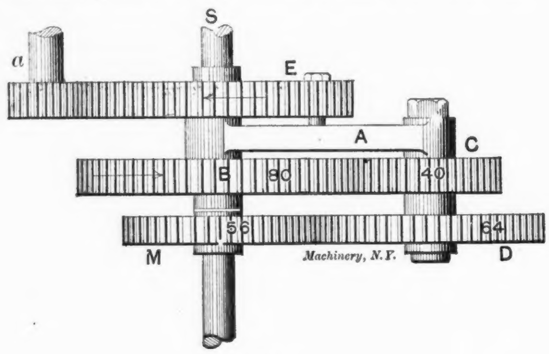


FIG. 5.

turns. All that now remains to be taken account of is the effect of turning the first gear once to the left and since the arrangement of the gears is such that left-handed rotation of B will produce left-handed rotation of M, we have simply to add —2 2-7, the number of times that M will turn for one turn of B to the —6 3-7 above, making —8 5-7 turns as the final result. The formula for a train of this character is:

Revolutions = 1 ± R ± N R, where N is the number of turns made by the first wheel for one turn of the arm and the sign of R is determined by the number of axes as before. The sign of NR is plus if B causes M to turn with the arm and minus if it causes it to turn in a direction opposite to the motion of the arm.

In this example

$$\text{Revolutions} = 1 - 2\frac{2}{7} - \frac{1}{5} \times 2\frac{2}{7} = 1 - \left(\frac{80}{35} + \frac{16}{35}\right) = -\frac{61}{35}$$

and this, multiplied by 5, for five turns of the arm, equals —8 5-7 as before.

The following table shows how the different steps for this problem may be tabulated for each gear of the train. The two operations opposite the lines "Arm Fixed" are first to balance the five turns of the arm and second to take account of the turn back-

ward of the first wheel. The fractions are from the number of teeth in the gears and for the purpose of working out the velocity ratios step by step. With these hints the student should be able to work out the table for himself.

	Arm.	Wheel B.	Wheels C and D.	Wheel M.
Train Fixed.	+ 5	+ 5	+ 5	+ 5
Arm Fixed..	0	− 5	$+ 5 \times \frac{80}{40} = + 10$	$- 10 \times \frac{64}{56} = - 11\frac{3}{7}$
" " ..	0	− 1	+ 2	$- 2\frac{2}{7}$
Totals......	+ 5	− 1	+ 17	$- 8\frac{5}{7}$

Effect of Internal Gear.

The effect of an internal gear in a train of wheels is to make the direction of rotation of the last gear opposite to what it would be if there were an ordinary spur gear instead of the internal gear. When a pinion meshes with an internal gear both turn in the same direction, whereas, two pinions running together turn in opposite directions.

In an epicyclic train with an internal gear the same effect is noticed when the motion of the arm is not taken into account; but if the motion of the arm be considered, the final direction of rotation of the last gear may or may not be changed according to the proportions of the wheels. The method of solution will best be illustrated by an example.

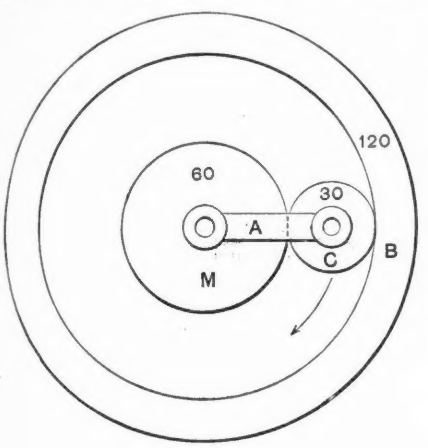


FIG. 6.

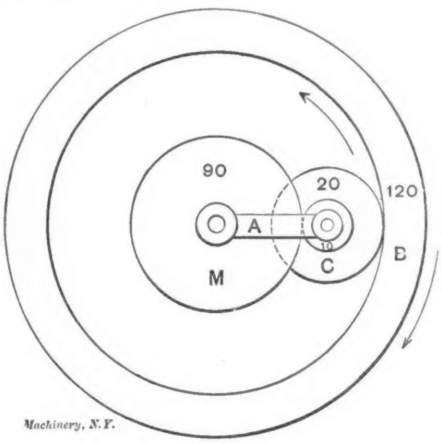


FIG. 7.

In Fig. 6 the arm A rotates about the center of M and carries with it the gear C which is in contact with both B and M. The velocity ratio of this train is $120 \div 60 = 2$, and the number of axes is odd, there being three, one for each wheel. According to our rule, the number of turns of M for one turn of the arm would be $1 - R = 1 - 2 = -1$, assuming the arm to turn to the right.

In the expression $1 - R$, the 1 refers to the motion of the arm and R to the velocity ratio of the train with the arm left out of account. Since, however, the effect of an internal gear is to change the direction of motion of the last wheel of a train, the sign of R above should have been changed, making the number of revolutions of $M = 1 + R = +3$. Having an internal gear in a train, therefore, changes the sign of the velocity ratio, R, as stated in the rule and this quantity must be added where the rule says to subtract and subtracted where the rule says to add.

The movements of this example are thus tabulated:

	Arm.	Wheel B.	Wheel M.
Train Locked..............	+1	+1	+1
Arm Fixed................	0	−1	+2
	+1	0	+3

It should be kept in mind that in the preceding analyses it has been assumed that the arm moves in a positive direction. In Fig. 7 is an example of an internal gear train in which the arm turns left handed. Here there are four gears of which B, having 120 teeth and the pinion ten teeth are the drivers and gears C and M, having 20 and 90 teeth respectively, are the driven wheels.

The velocity ratio of the train is $\dfrac{120 \times 10}{20 \times 90} = \dfrac{2}{3}$

Required to find the number of turns made by M when B makes plus five turns and A makes minus six turns.

There is no difficulty whatever in solving any problem of this sort by the tabular method, no matter which way the arm rotates. Thus, with the wheels and the arm locked together, turn all of them around the central axis—6 times, as indicated in the first line of the table below. Then turn wheel B back +6 times, since this wheel was to remain stationary, as shown in the second line. Finally turn B + 5 turns more to comply with the conditions of the problem, and add the columns to get the final results.

	Arm.	Wheel B.	Wheel M.
Train Locked............	−6	−6	−6
Arm Fixed..............	0	+6	−6×2-3=−4
" "	0	+5	−4×2-3=−3 1-3
	−6	5	−13 1-3

If an analytical solution be desired, it is best to assume the arm to have postive motion and then change the sign of the answer if the motion of the arm was actually negative. We have the expression $1 \pm R \pm NR$ where N is the number of turns made by the first wheel for one of the arm. The sign of R is determined as before and NR will be plus if the first wheel causes the last wheel to turn in the same direction as the arm, taking the directions as stated in the example, and minus if it causes it to turn in an opposite direction.

In this example, number of axes is odd and motion of arm and last gear are the same. Hence 6(1 + 2-3) + 5 × 2-3 = 13 1-3. But as the motion of the arm was negative instead of positive, the sign of the result should be changed, making —13 1-3.

Bevel Gear Train.

Perhaps the most interesting adaptation of epicyclic gearing is to the bevel gear train, which is shown in principle in Fig. 8. Here gears B and M are loose upon the shaft and mesh with two gears, C and D, which are carried by gear A, corresponding to the arm of the spur gear trains. This gear, A, is fast to the shaft and revolves with it.

There are four different conditions that can exist with a train of this character. First, let the gear or arm A be fixed and both B and M free to turn. Gears C and D then act as intermediate bevel gears and B and M will turn at the same speed but in opposite directions. In the transmission of power from one gear to the other the force tending to rotate the gear or arm, A, is just half the force transmitted from B to M. Second, suppose B to be fixed and M to be driven from outside, gear A being free to revolve with its shaft. It is clear that A will make only one-half as many turns as M and in the same direction. Again, third, if M be fixed and B the driver, A will turn one-half as many times as B and in the same direction. Suppose both M and B to have independent motions and A to be free to revolve. If M and B move in unison in the same direction, they will simply carry A

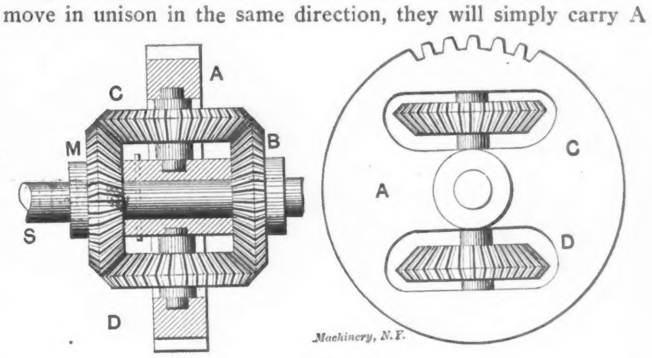


FIG. 8.

along with them. If one moves faster than the other A will follow that one. If they have motion in opposite directions and at the same speed, A will remain stationary and if either B or M moves faster than the other, A will follow that gear as before, when they were turning in the same direction. The amount of motion of A will be equal to one-half the angular motion gained by either of the other gears.

In a later number it is hoped to illustrate some of the applications of epicyclic trains. These applications are numerous and varied and in many instances results can be accomplished through their use that would be difficult if not impossible without them.

ANOTHER POWER PRODUCER.

Apparently one of the most difficult things for the average man to understand is the theory of conservation of energy and the fact that by no form of mechanical juggling can more power be realized from a machine than is put into it in some form or other. In fact the efficiency of any machine is always less than 100 per cent. from the inevitable loss of some portion of the energy by the ever existent frictional effect. But in spite of these well-proven facts, the appearance of motors which are guaranteed by their sanguine inventors to produce impossible results is perennial. One of the latest candidates for honors hails from Elmira, N. Y., instead of Philadelphia, the home of the "lamented" Keeley and a number of other inventors of more or less shady reputation. The Elmira machine is a "hydraulic engine," which merely appears to be a three cylinder engine having the cranks set at 120 degrees and with air chambers to absorb the water hammer which would have a destructive effect without this provision. Although this engine has three cranks and three slide valves besides numerous supplementary moving parts, and is covered by twenty-six patents, the public is gravely assured by the guileless promotor that it has an efficiency of 185 per cent. While we do not believe that any machine could show such a wonderful efficiency, it is simply out of the question to ask the suffering public to believe it could when so loaded down with patent protection.

The circular issued in the interests of this unique machine proves to be very interesting and entertaining reading as for an example: "This engine develops all the power which is in the weight and momentum of the water, using much less water and exceeding largely the power obtained by the ordinary water motor or turbine wheel whose power depends on the weight of the water alone." "The pressure produced by the momentum of the water in the supply pipe is stored for use in the next stroke of the engine. The pressure obtained is two or three times the supply pressure or even more. The average pressure in the cylinder is much greater than the pressure in the supply mains and the engine thereby develops power in excess of the pressure in the mains."

We are assured that this engine has no competition and that the patents are very valuable, but that it is highly desirable to increase the present capital from $300,000 to $500,000 in order to properly introduce this wonderful machine which can be used in any town having a water supply system. We are also told that many mines in the West are closed on account of not being able to produce power at a reasonable cost. It is evident to any practical man that if water is at all available for power in these mines, that the ordinary turbine while not having an efficiency of 185 per cent. would certainly be of some assistance in solving the power problem.

The circular states that the amount of water used by the "hydraulic engine" is so small that there cannot be the slightest objection to its use in any town even for heavy power purposes, but it appears to the writer from a careful investigation of the input and the output claimed, that by the addition of a return pipe from the discharge there ought to be no need of any connection to the main at all. Any machine that can take 100 units of power and transform them into 185 ought not need to be tied down to any city water main. There is a possibility of something akin to independence of this sort hinted at in this remarkable statement. "This engine we firmly believe will revolutionize the question of stationary power and will largely take the place of all other motive power. This engine can be used on boats if the waste water can be taken care of." It would certainly be interesting to know why the discharge water could not be run overboard, but no inkling is given of the reason or of the source of the water supply.

Let us hope that the time is not far distant when by reason of a more general knowledge of first principles the exploiting of such impracticable schemes will be out of the question and scant notice be given to any device that promises something from nothing.

* * *

It is a poor shop that does not have some method, scheme or device worth publishing. Do not think that because your shop methods are perfectly familiar to you that they are known to everyone else, but send them in, and we will do the rest.

MACHINE TOOLS—THEIR CONSTRUCTION AND MANIPULATION.—1.

W. H. Van Dervoort.

In taking up the subjects pertaining to machine tools their construction and uses, a classification showing the general subdivisions of the work commonly performed on metal working tools is briefly outlined as follows:

First—Turning and Boring; as performed in the lathe, screw-machine, turret-machine, vertical boring mill, etc., in which the work is usually made to rotate to a cutting tool or tools which, aside from feeds, are stationary. This operation usually produces curved or circular surfaces, both internal and external, but may, as in facing, produce a plane surface.

Second—Planing Operations; as performed on the planer, shaper, slotting machine or key-way cutter, where the work is given a straight line motion to a stationary tool, or, as in the three latter types of machines, the tool is given a straight line motion over stationary work. In the former case the feeds are given to the tool while in the latter the work usually receives one or both of the feeds. In the case of the traverse head shaper, however, the tool is given both feeds over perfectly stationary work.

Third—Milling Operations; as performed on the various types of milling machines where a rotating cutter produces plane, curved or formed surfaces on the work, the latter usually receiving the feeds.

Fourth—Drilling; the forming of circular holes in solid stock by means of a revolving tool at one operation, the tool usually receiving the feed. Drilling differs from boring in that the latter term applies to the enlarging and truing of a hole already formed.

Fifth—Grinding; these operations involve the removal of metal and finishing of the surface by an abrasive process, the material being ground rather than cut away. The universal and surface grinding machines correspond with the lathe and planer, a rotating wheel of emery or corrundum taking the place of the cutting tool in the latter machines. Grinding operations, although necessarily slow, make possible the accurate finishing of the hardest metals.

Sixth—Punching and Shearing; under this heading may be included all tools used for the punching and shearing of metals and although not strictly in this class, we may include presses used for stamping and forming purposes.

The scope of these articles will not permit going too much into the details of machine tool construction. It is, however, hoped that the principal points of construction and methods of operation may be brought out clearly and in such a way as to aid the young mechanic in quickly becoming master of the several classes of machine tool operations above enumerated.

That most important of all machine tools, the lathe in its several forms, naturally comes first for our consideration. The great variety of work that can be performed on the lathe, and the efficient way in which it is done, are the considerations upon which its importance depends. The young mechanic, when complete master of the lathe, as used in general work, will have learned nearly all the principles involved in the operating of the other classes of ordinary machine tools.

For special work the lathe is so modified to meet the particular conditions that its identity is almost lost. For example, the turret lathe, the screw machine, the pipe threading machine, the cutting off machine and even the vertical boring mill are all modifications of the lathe in which the principle of rotating the work to a stationary cutting tool is carried out.

The speed, or hand lathe, an example of which is shown in Fig. 1 is the simplest form of metal turning lathe. It is a single geared lathe which means that the cone is secured to the spindle, the number of changes in spindle speed depending upon the number of steps on the cone. The tool rest is adjustable in all directions, but not provided with feeds. These lathes, when provided with foot-power mechanism, may be driven by the operator. They are, however, usually furnished with a countershaft and driven from some other source of power. The hand lathe is used for all classes of turning operations in which a hand tool is used. They are also used for drilling, filing and polishing rotating work. When used largely for drilling, the lever operated tail stock spindle is of value.

The standard engine lathe as shown in Fig. 2 and so exten-

FIG. 1

sively used for general shop work, is in the smaller and medium sizes a double-geared screw-cutting lathe. In the larger sizes triple, or quadruple gearing is used instead of double, the term double, triple and quadruple referring to the number of speed reductions in the back gearing. The term self-acting implies that the cutting tool is automatically actuated in all of its feeds.

The lathe primarily consists of four elements—bed, head-stock, tail-stock and carriage. The bed is the foundation upon which the other elements operate over accurately planed and fitted shears. It should be well designed, heavy and rigid. The deflection due to its own weight and the pressure of the cut must be within very narrow limits. The form of shears used, on engine lathes, almost without exception, is shown in the cross section of bed, Fig. 4. The head and tail-stocks rest upon the inside pair and the carriage on the outer pair. This view also shows the cross section of bed usually employed. It consists of two parallel I's tied at frequent intervals by the cross girts shown. Beds, when short, are supported on legs at the ends as shown in Fig. 2, but when the length becomes excessive and material deflection due to its own weight would result, one or more intermediate supports are introduced.

The head-stock contains the mechanism that receives and transmits the power through the spindle to the work. Its important features are the retaining head and spindle bearings, spindle, cone, feed-screw and back-gearing. The retaining head should be so formed as to best resist the heavy strains to which it is subjected. It should be properly fitted to the inner shears and clamped in place. The live spindle and spindle bearings are the most important elements in the lathe, as the accuracy of the work produced depends very largely upon the accuracy of the spindle. It should be cylindrically true, accurately fitted in its bearings and its center of rotation exactly parallel with the shears. The threaded nose and center bearing must be exactly concentric with the bearing parts of the spindle. The cone should be given a nice bearing fit on the spindle and the back gears properly cut and pitched. The feed and screw cutting gear should be reliable and powerful. The head-stock of the lathe shown in Fig. 2 illustrates the general form as used in double geared lathes.

The live-spindle bearings are usually made of bronze or genuine Babbitt metal. When the latter material is used it is after being cast in the casing, peaned sufficiently to fill out any shrinkage as well as to intensify the metal, after which it is bored, reamed and carefully bedded by scraping to an accurate fit on the spindle. The Babbitt bearing as used on the lathes by the F. E. Reed Co. is shown in Fig. 3. In order to reduce the wear to a minimum the spindle bearings should be large. Provisions for taking up the wear are, however, always necessary. The end thrust of the spindle is usually taken at the end bearing, an adjustable thrust screw receiving the pressure. The modern engine lathe is usually provided with a hollow spindle, the size of the hole often being as large as the diameter of the spindle will safely permit. This is frequently a point of great value in working up stock that will pass through the spindle. All back-geared lathes may be run as single geared lathes by locking the cone with the spindle gear. The purpose of the back-gear is to reduce the speed of the spindle and correspondingly increase its pull. Thus, with a five step cone running single geared, five changes of speed can be had, the speed reducing and the leverage increasing as the belt is shifted from the smaller to the larger steps. If, for example, the smallest step is 6" and the largest 18" in diameter and the countershaft cone has steps of the same diameter, as is commonly the case, then, if the belt is running on the large step of the spindle cone, which is making say twenty-five revolutions per minute, a shift to the smallest step will give, if the belt continues to run at the same speed, $3 \times 24 = 75$ revolutions per minute, but in shifting to the small step on the spindle cone, the belt goes to the large step of the counter cone, which, since the counter runs at a constant number of revolutions per minute, increases the belt velocity in the ratio of 6 to 18, or three times, and consequently the spindle will revolve $3 \times 3 \times 25 = 225$ times per minute. If now the back gear is thrown in, five more reductions in speed may be had. In Fig. 5 is shown an outline of the double gear arrangement. The cone, when back-gear is in, is disengaged from the spindle gear D, which allows it

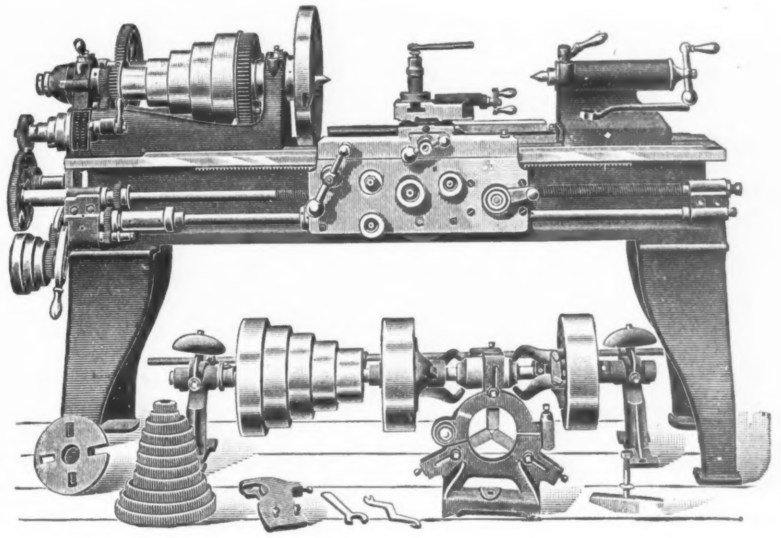


FIG. 2.

to rotate free on the spindle. Gear A of say 30 teeth is secured to the cone revolving with it, A gears with B of 80 teeth, B and C rotate together, C of 20 teeth gears with D of 90 teeth, and since D is keyed to the spindle the latter is driven by the cone through the chain A, B, C and D. If we assume as before that the belt is on step F and the spindle makes 25 revolutions per minute,

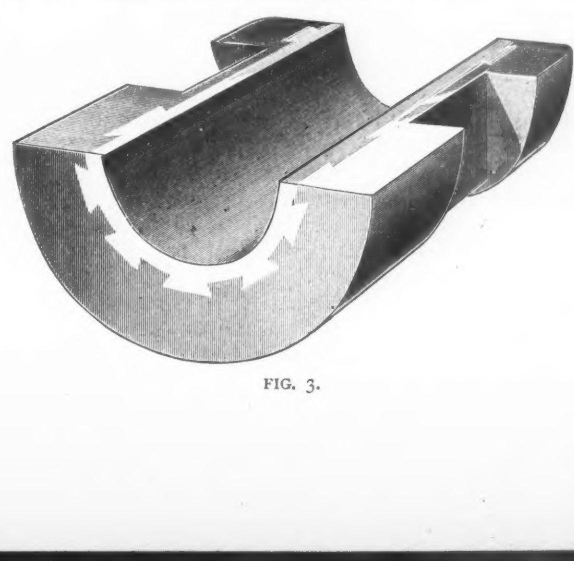
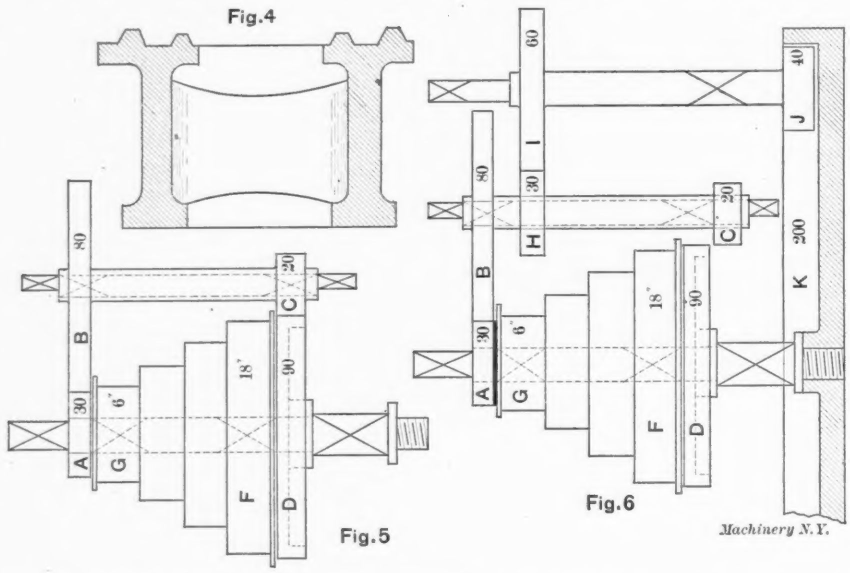


FIG. 3.

putting in the back gear decreases the rotation of the spindle by the amount of the back gear ratio = 30-80 x 20-90 = 1-12, which would give 25 × 1-12 = 2 1-12 revolutions per minute. If on the small step of the cone, it would be 225 × 1-12 = 18¾ revolutions.

In outline, Fig. 6, is shown the usual triple gear arrangement. Let A, B, C, D, F, G respresent the same values as in Fig. 5. If I and J are thrown out by moving them through their bearings in the direction of the arrow and C thrown into gear with D, we would have the same conditions as in Fig. 5. When arranged as shown in the figure, however, H corresponds to C, and I to D, J rotates with I and gears with the internal gear on the back of the face-plate and thus gives a second geared



reduction. The velocity ratio would then be 30-80 × 30-60 × 40-200 = 3-80 or for the 25 revolutions of the cone in the former example the spindle would revolve 25 × 3-80 = 15-16 of one revolution.

In large lathes performing very heavy duty, the application of the power to the circumference of the face-plate steadies the cut and removes the excessive torsional strain that would be thrown upon the spindle if all the power was transmitted through it.

The tail-stock, or foot-stock as it is frequently called, is accurately fitted to the inner shears. It can be moved along the shears and clamped firmly to them at any point. The function of the tail-stock is to carry the tail or dead spindle. This spindle fits its bearing closely, can be moved in or out through a considerable range and clamped in any position. The axis of the dead spindle extended should be coincident with the axis of the live spindle. The dead spindle is always provided with a cross adjustment commonly called the set over and much used for turning external tapers on work held between centers.

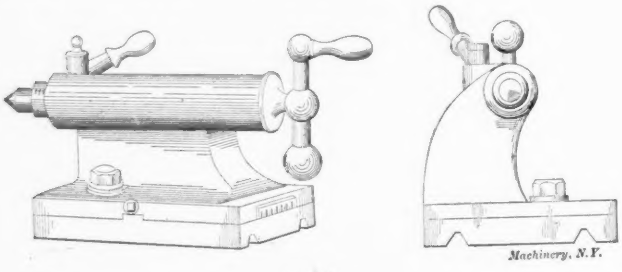


FIG. 7.

A form of tail stock largely used in Europe is shown in Fig. 7. It is becoming quite popular among American builders. Its leading advantage is in its use on a lathe having a compound rest as it allows the rest to swing around parallel with the shears and still get in reasonably close to the center when the tail-stock is close up to the carriage. It is commonly called the "cut away" tail-stock.

The carriage is the tool carrying device and stands next to the head-stock in importance. It rides, as shown in Fig. 8, on the outer shears and is gibbed front and back to the outer under faces directly below the shears. Gibbing to the inner under faces and weighting the carriage have given over to the better practice above referred to. The old weighted carriage in which a heavy weight suspended from the bottom held it to the shears precluded the possibility of cross girts to stiffen the bed and increased the wear between shears and carriage. The apron on the front side of the carriage contains the feed mechanism and, with the exception of the make of lathe of which Fig. 8 shows the carriage, the lead screw open and shut nut. The details of the apron vary considerably all, however, being intended to accomplish the same results. In general, motion is transmitted from the splined feed rod through a keyed sleeve which slides over the rod and carries a bevel gear which connects through a clutch and suitable train of gear to the pinion which engages the rack on the under front edge of the top of bed. In a similar manner the motion is communicated to the pinion on the cross-feed screw. By engaging either clutch the feed that it controls will operate.

A suitable clamp for securing the carriage to the shears for cross-feed work is always provided. The most common method is to pinch either the front or back gib, the square head screw shown on the top right-hand side of carriage in Fig. 8 being for this purpose.

The slide rest which carries the cutting tool is gibbed to a cross shear which is exactly at right angles to the spindle. In its simplest form the slide rest is a single piece carrying the tool post or clamp. This forms the most rigid rest, it having but the one gibbed joint The raise and fall rest is shown in Fig. 9. It is a form of elevating rest. In Fig. 10 is shown a compound rest. This form, while not as rigid as the plain rest, has become very popular among machinists, because of its points of convenience. It has the regular automatic cross-feed and the auxiliary feed which can be operated at any required angle with the spindle. This latter feed for the larger lathes is frequently made automatic. The manner in which it is accomplished by the Putman Machine Co., on lathes from 22 to 42 inch swing is shown in Fig. 11. Here the splined cross-feed screw carries

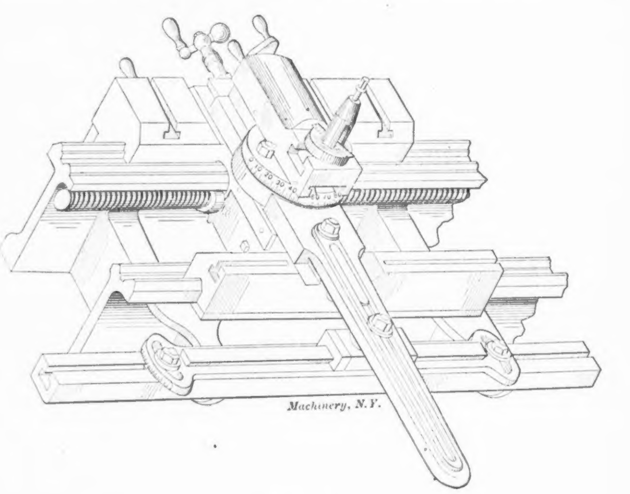


FIG 8.

a sleeve, which, by means of an eccentric operated by the handle at the left, can be clutched with one of the four bevel gears that transmits the motion to the nut.

* * *

Aluminum was once a rarity in the chemical museum, then a commercial material at many dollars a pound, ranging almost with the precious metals, and all at once brought by the methods of practical electro-chemistry into the market as a commercial product with innumerable applications in the arts. There is something curious in the fact that a metal, which applied electricity made possible in the markets is likely to become a rival of copper as an electrical conductor, and thus we find electricity supplying the materials for its own utilization.—*Engineering Magazine.*

HIS THEORY IS CORRECT.

Major James M. Ingalls, the artillery expert of the United States Army, has calculated that the range of the great 16-inch 126-ton gun now building for this government will be nearly twenty-one miles. As this is the distance "on paper" only, it may be assumed by some that these figures are largely guess work and that nothing definite can be determined until the gun is fired. The science of artillery, however, has been brought to a more exact basis than it would seem that the varied conditions would allow. The ability of the major to figure accurately, is vouched for by the "Scientific American," in which is related the following account of a test calculation which he made for the English government:

"One of the greatest ranges ever attained was recorded by a 9.2-inch English gun at Shoeburyness, England. The gun was fired on the occasion of the Queen's Jubilee, at 12 o'clock noon. Several months before the date of firing, the English officials sent out data to the recognized artillery experts of foreign countries, and the request was made that the range of the shell be calculated. Major (then Captain) Ingalls was handed the English data, as the officer selected to solve the problem for the United States army. Major Ingalls worked alone, and when his calculation was made, it was duly sealed and forwarded through the diplomatic channels to the British War Department.

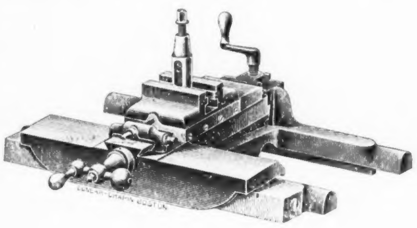


FIG. 9.

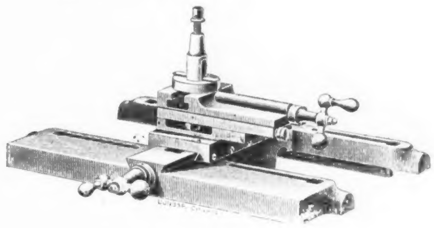


FIG. 10.

"It was understood from the first that the papers were not to be opened until after the shot had been fired. To enable the foreign officers to calculate the more closely, the English authorities furnished all possible data in advance which might be needed. The data set forth the type of gun, weight of shell, nature and weight of charge, angle of elevation, and a table of atmospheric readings, showing what conditions had prevailed at Shoeburyness for ten years back for the hour on corresponding days on which the shot was to be fired.

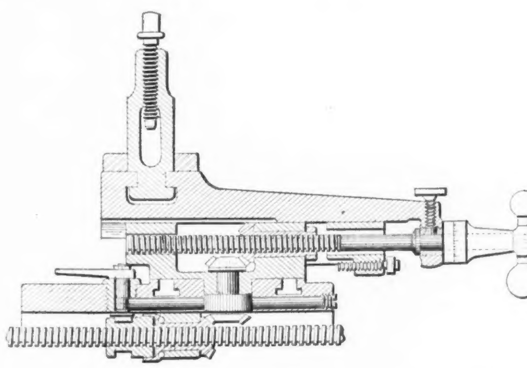


FIG 11.

"The range attained by the English shot was about twelve miles. When the papers of the foreign officers, as well as those of the English officers, were opened, it was found that the closest calculation of all had been made by Captain James M. Ingalls. The next best calculation was turned in, it is understood, by an Italian artillerist. Captain Ingalls plotted the fall of the shot only a few hundred feet short of the actual distance. The rival calculations placed the point of fall at distances varying from 1,500 yards short to several miles short. On overlooking the data of the firing with the actual conditions of weather which prevailed at Shoeburyness, on the day in question, Captain Ingalls was able to place the shell practically at the very spot where it struck. In his previous calculations he had worked up the problem, using the mean average atmospheric data for the ten years past. From the artillerists' standpoint, Ingalls' wonderful showing has never been equaled."

MURPHY'S RIDE.

All the sporting readers of this paper, know that Chas. M. Murphy made a mile in 57.8 seconds on June 30, on a bicycle which he rode on a board track built between the rails on a stretch of the Long Island Railroad. Murphy rode directly in the wake of a car with a protecting hood extending over and on each side of him, thus shielding him from the effect of wind. The car was drawn by a locomotive which the engineer was directed to run over a mile a minute. The run seems to have demonstrated the ability of Murphy to keep his feet on the pedals and make his legs go at a mile-a-minute pace, rather than anything else, since the effect of the car must have been an important factor in helping him along. An easier way to have made the test would have been to have mounted the wheel on a standard, put a gentle brake load on the rear wheel, attached a speed indicator and then to have told Murphy to mount the wheel and keep the indicator up to a certain height. This in our opinion would have been quite as fair a trial as the other one.

A few figures showing the effect of the air resistance upon a bicyclist and what power he must exert in order to overcome this resistance will clearly demonstrate of how little consequence a trial like that of Murphy's is, although the available information upon which to base calculations is rather meagre.

What is probably a reliable formula for wind pressure or air resistance is that of Whipple and Dines, given in Kent's pocket-book: $P = .003\ V^2$, in which P = pressure in pounds per square foot, and V = velocity in miles per hour.

A number of riders have succeeded in making a mile in about two minutes, without being paced, so that they met with the full resistance of the air. Since there are 5,280 feet in a mile, one pound of air resistance would amount to 5,280 foot-pounds of work done per mile and if, as assumed, this distance be covered in two minutes there would be $5.280 \div 2 = 2,640$ foot-pounds developed in a minute. 33,000 foot-pounds per minute equal one horse-power and therefore the one pound resistance would result in an expenditure of $2,640 \div 33,000 = .08$ horse-power, assuming a perfect efficiency. But as the bicycle and tires would not have an efficiency of over 80 per cent., the power that would have to be exerted to overcome the one pound pressure would be $.08 \div .80 = .10$ horse-power.

Applying the air pressure formula, however, we find that instead of one pound air resistance at thirty miles an hour, the rider would have to overcome 2.7 pounds per square foot of vertical or projected surface exposed, and if, in the riding position, he had the equivalent of two feet front exposed, the total resistance would be $2.7 \times 2 = 5.4$ pounds. This, multiplied by .10, the horse-power required to overcome the one pound resistance, gives .54 as the horse-power that a man would have to exert for two minutes to make a mile in that time.

This is probably rather more power than a man could exert during an interval of two minutes. Experiments show that an exceptionally powerful man can develop two-thirds of a horse-power for a few seconds, but the bicycle tests published in the July, 1898, issue of this paper indicate that a strong and experienced rider traveling at the rate of ten miles an hour can develop only .20 horse-power per mile, continuously. For a spurt of two minutes, therefore, we should not expect a man to develop over a half horse-power at the most. From this reasoning it can be predicted that the present mile record without a pacer will not be greatly lowered.

Turning, now, to Murphy's mile-a-minute gait, the wind pressure that he would have had to overcome would have been $.003 \times 60 \times 60 \times 2 = 21.6$ pounds and the horse-power required to overcome this resistance would have been $21.6 \times .10 = 2.16$, or several times beyond the strength of a strong man. By having the hooded car for a pacer, however, he was relieved of most of this resistance and was able to make the mile in less than a minute with comparative ease. Thus Murphy's ride, while made in fast time, was not in the truest sense a record breaking feat.

* * *

A rectangle is a plane figure having four sides and four angles each of which is a right angle. Thus a square figure is a rectangle but a rectangle is not necessarily a square.

PRACTICAL PROBLEMS.—10.

PROBLEMS 19 AND 20 WITH ANSWERS TO PROBLEMS 17 AND 18.

Problem 19.—To calculate the diameters of the steps for a pair of cone pulleys.

The diameter of the middle step on pulley A is 8", which bears the ratio of 4.5 to the middle step of pulley B. The steps are to be so graded that a constant geometrical progression will be obtained in the speed with a multiplier of 1.6. This means that when the belt is on the largest step of A, the number of rotations

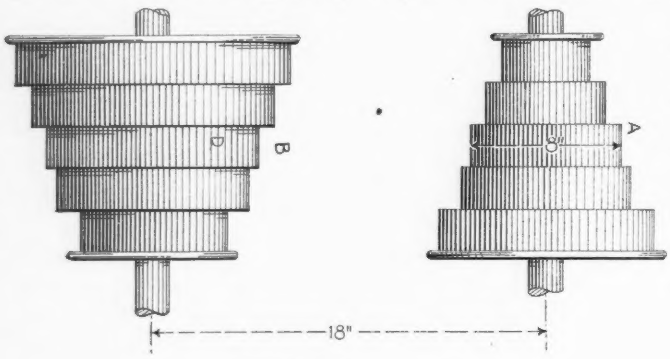


FIG. 1.

of B will be 1.6 times greater than when the belt is on the next step and again the number of rotations of B is 1.6 times greater with the belt on this step than it would be on the next. So the ratio between the speeds when the belt is on the largest and the smallest step is as 1: (1.6 × 1.6 × 1.6 × 1.6) or as 1: 6.55 +. What will be the diameters of all the steps when the center distance between the shafts is 18"?

Problem 20.—To find the diameters of the steps for a crossed belt.

What would be the diameters of the steps in problem 19 if the belt were crossed instead of open and also what is the length of belt required in each problem?

ANSWERS TO PREVIOUS PROBLEMS.

Problem 17.—In answer to this problem "Technical," Ithaca, N. Y., says that since the mean diameter of the screw is 1⅜", its mean circumference is 1⅜ × 3.1416 = 4.3195" and since the screw has right and left threads of ¼" pitch, two turns will be required to cause the nuts to approach each other 1". That being the case, the threads of the screw will traverse a distance practically of 2 × 2 × 4.3195" = 17.278" in their nuts. The efficiency is found by dividing the tension of the screw to pull the

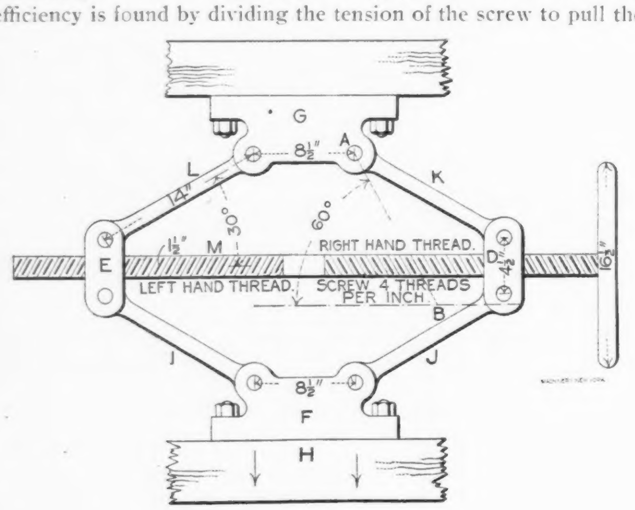


FIG. 2

knuckle joints together by the resistance which is equal to the tension plus that necessary to overcome the loss from friction. Since the co-efficient of friction is given as .08, the loss can be found and more clearly understood by assuming some definite tension on the screw. If we assume this tension to be 100 pounds, it is evident that for one inch of circular movement of the screw in the nuts, there is a loss of 100 × .08 = 8 inch pounds, and as it is necessary to turn the threads a total distance of 17.278" for 1" of travel for the nuts, the frictional loss with a tension of 100 pounds would be 8 × 17.278 = 138.224 inch pounds. The efficiency is then 100 ÷ (138.224 + 100) = 42 per cent nearly.

Problem 18.—Solved by "Technical," Ithaca, N. Y., as follows: The circumference of the wheel in Fig. 2 is 3.1416 × 16.5 = 51.83" and as two turns of the screw are required to cause the nuts to approach each other 1", the ratio between the travel of the rim of the wheel and the nuts becomes 2 × 51.83 = 103.66 to 1. Since the pull on the rim of the wheel is given in the problem as 50 pounds, the theoretical force tending to draw the nuts together is 50 × 103.66 = 5183 inch pounds, but as the efficiency as calculated is 42 per cent., the effective force would only be 2176.8 pounds.

The proportion between the resistance and the pressure in a double toggle joint is R : P : : cos x : sin x or R sin x = P cosin x. Now in the first position given, the angle between the arms and the axis of the screw is 30°, but the angle referred to in the proportion is that which the arms make with the straight line joining their outer ends so we have 60° for angle x in this case. From a table of sines and tangents we find that the sine of 60° is .866 and the cosine is .5, therefore:

.866 R = 1088.4 pounds

R = 1256.8 pounds the force exerted on the platen with the arms in the first position.

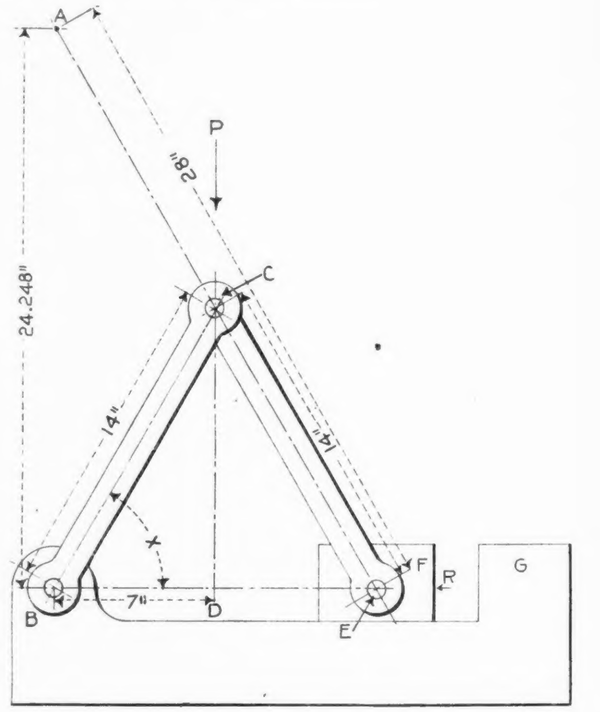


FIG 3.

In the second position given by the problem, the angle between the arms and the axis of the screw is 60°, so the angle between the arms and the lines joining their outer centers is 30° and as the sine of 30° is .5 and the cosine is .866, we find by the same equation used before that R = 3770 pounds.

The force exerted on the platen in the second position is, therefore, three times that exerted in the first position, and it increases with the lessening of angle x until x equals zero when the theoretical resistance that could be overcome by a pressure on the toggle joint would be infinity.

A second method of finding the resistance that could be overcome is shown graphically in Fig. 3, which shows the simple toggle alone without the screw. The angle x is laid out at 60° with the line B E joining the outer ends of the arms and the line B A is erected at right angles to it. The center line F C is extended until it cuts A B and the perpendicular C D is drawn to B E.

The distance A B : B D : : P : R or 24.248 : 7 : : 2176.8 : R

R = 628.4 pounds

2R = 1256.8 pounds

Solutions to problem 16 have also been received from D.W.S., Manhattan, Kansas; C. Albert Nettengel, Pittsburg, Kansas, and from James Morse, Chicago, Ill. Mr. Z G. Houck, of Belleville, Ill., also sent a solution to problem 16. As this problem has been sufficiently explained it will not be necessary to publish any of these solutions.

MARINE ENGINE DESIGN —8.

CONDENSERS.

William Burlingham.

Marine condensers may be considered as belonging to one of two principal types, the surface and the jet condenser. The jet condensers have long been relegated to the background for marine work, the surface condenser being the only type that it is possible to use with a reasonable degree of economy.

In a jet condenser the condensing water mixes directly with the exhaust steam, the water entering in thin sheets through saw-like cuts, or in tiny jets, thus affording a large surface for the exhaust steam to strike against. This steam, entering the same chamber as the water, is condensed, and the condensing water and water of condensation, or condensed steam, in other words, are pumped out together by the air pump.

The form of the jet condenser makes but little difference, and depends in a great measure upon the type of engine to which it is fitted. The main requirements are that all the water shall drain into the pump and that the inlet for the condensing water shall be so placed as to obviate any danger of water entering the cylinders of the engine.

The average capacity of a jet condenser should be about one-third that of the cylinders exhausting into it. In a climate of medium temperature the amount of condensing water necessary is about thirty times the weight of the steam used. The principle of the surface condenser is entirely different from that of the jet. The condensing water is kept entirely separate from the exhaust steam, and is conducted through a series of tubes of small diameter. The exhaust steam impinging upon the outside of these tubes is condensed by the cool metallic surface and drops to the bottom of the condenser as water.

The condensing water is either pumped from the ocean by a circulating pump, so called; or as in the case of the torpedo boats, the speed of the boat forces the water up through the condenser through a scoop riveted to the outside of the ship.

A variation of the ordinary type of surface condenser is used on small yachts and launches, and is called a keel condenser. In this type the exhaust steam flows through a pipe laid parallel to the keel and outside the hull.

In the majority of merchant ships the condenser body is made of cast iron and forms a part of the engine framing. The large liners, however, and the government ships, have separate condensers of cylindrical section, with shells of steel or brass plate.

In designing a condenser it is first necessary to know the quantity of steam that we have to condense, and consequently the amount of circulating water necessary for this purpose.

Quantity of Condensing Water Required.

Exhaust steam contains a certain definite amount of heat. As this heat must be extracted before the steam will condense, quantities of cold sea water are introduced through the tubes of the condenser, which have been raised in temperature by the heat extracted from the steam. Therefore the quantity of sea water necessary for circulating purposes depends directly upon the initial temperature of the water, compared with that of the steam.

The temperature of sea water varies considerably in different parts of the world, and even in the temperate zone there is a difference of from 40 to 50 degrees Fahrenheit at different times in the year, while in the gulf ports there is often a variation of as much as 80 degrees. A ship built for cruising in southern waters should have more condensing surface and allow for more circulating water than in the north.

In the tropics the amount necessary is about three times that used in the temperate zone.

The ordinary, but perfectly reliable formula, is as follows: It is usually given in text books, but with the information lacking that is necessary to make it of value to a practical man; that is, the ordinary temperature of sea water, of feed water, and of the water leaving the condenser.

The formula is as follows:

Q = quantity of cooling water per pound of steam.

T_1 = temperature of steam entering condenser.

L = latent heat of same.

T_0 = temperature of circulating water.

T_2 = temperature of water leaving condenser.

T_3 = temperature of feed water, or water pumped from the condenser by the air pump.

All the above temperatures should be absolute; that is, 460° + Fahrenheit temperature. For example, if the temperature of the circulating water is 62°, T_0 in the formula would equal 523°. The heat absorbed by the cooling water is $(T_1 + L) - T_3$, and this amount of heat must equal $Q\ (T_2 - T_0)$. Forming an equation and reducing to simple form, we have the formula:

$$Q = \frac{1114 + (.3 \times T) - T^3}{T_2 - T_0}. \quad \text{Formula A.}$$

For temperate zones:

T_0 varies from 65° in the summer to 40° in winter. For all around boat use 60 degrees. T_2 varies from 110 to 120 degrees, and T_3 from 115° to 130°.

For tropic and southern waters:

T_0 varies from 80 to 50°; for general purposes use 70°; T_2 and T_3 will vary proportionately.

The "Q" thus obtained is the number of pounds of water required to condense one pound of steam.

To find the amount of steam entering the condenser use the following formula:

Qs = amount of steam in cubic feet.

A = area of high pressure cylinder.

S = stroke in inches.

C = cut-off, usually taken at 72 per cent.

R = revolutions per minute.

$$\text{Then } Qs = \frac{A \times 2S \times .72 \times R}{1728}. \quad \text{Formula B.}$$

Multiply Qs by the weight of steam per cubic foot at the pressure entering engine, "to be found in the steam tables in the ordinary handbook," and the result is pounds of steam used per minute. Multiplying this result by the Q obtained in formula A, we have pounds of circulating water required per minute.

A gallon of fresh water weighs 8 1-3 pounds.

A gallon of salt water weighs $8\frac{1}{2}$ pounds.

Gallons of circulating water required is equal to the

$$\frac{\text{pounds of circulating water}}{8\frac{1}{2}}$$

These separate formulæ may be combined in a general one, if considered advisable.

The capacity of the circulating pump for naval work is taken at the rate of 50 pounds of circulating water per pound of steam. This is much more than is needed for the condensation, and is only necessary because the circulating pump must be used in cases of emergency for pumping out the bilge of the ship. For merchant ships the ratio will vary from 40 to 50.

The actual quantity of water required for condensing purposes in temperate zones is about one-half of this, say from 20 to 25 times the weight of steam used. The speed of the circulating water through the tubes is about 125 feet per minute for naval work and from 90 to 100 in merchant work. The diameter of the inlet and outlet pipes should be such as to give a speed to the water of not more than 800 or 1,000 feet per minute through the pipes.

Proportions and Specifications for the Tubes.

The length of the unsupported tube should not exceed 120 diameters when held by the ordinary screw ferrule and cotton tape packing. This is the limit of length, and a better working ratio would be from 100 to 110 diameters. If made longer than this, supporting plates of the same material as the tubes should be used. These plates must be so arranged that they will not hinder the free flow of steam to the various parts of the condenser. They are oftener placed so as to act as baffling plates as well as for supporting the tubes. The materials of the condenser in contact with the circulating water should, if possible, be made of the same composition, to obviate in some degree the galvanic action. Slabs of zinc are also secured inside the condenser to protect the composition from pitting, etc., due to this same action. The principle upon which this zinc acts is as follows: The zinc and composition with the salt water generate an electrical current, which galvanic action eats away the zinc, and in so doing leaves the composition untouched. If the zinc were not there the composition would be attacked and deeply pitted.

The cooling surface of the tubes required in a condenser for a horse-power varies considerably, and in the usual design it is fixed by empirical figures that long experience has proven to be correct.

For torpedo boats, allow .75 of a square foot per horse-power,

battleships and cruisers, 1.35 square feet, and for merchant work about 1.5, although the condensers for merchant ships vary more than the other classes. For a well-designed merchant engine 1.4 square feet would be amply sufficient.

The tube plates for cast-iron condensers in merchant work are usually made in one piece, of rolled brass, and for naval work with muntz metal tubes they are rolled of muntz metal.

In some of the large condensers, where the tube plate was too large to be rolled, they were cast on end of government composition, 88 copper, 10 tin and 2 zinc, and planed to the required thickness. This method gives very fine results.

The tests of the composition of the tubes for use in the navy are as follows:

They shall be made of muntz metal, compounded of new materials, 60 per cent. pure copper and 40 per cent. of pure zinc. All tubes shall be of ⅝ inch outside diameter, and No. 18 B. W. G. in thickness.

One per cent. of the tubes shall be selected at random from the lot.

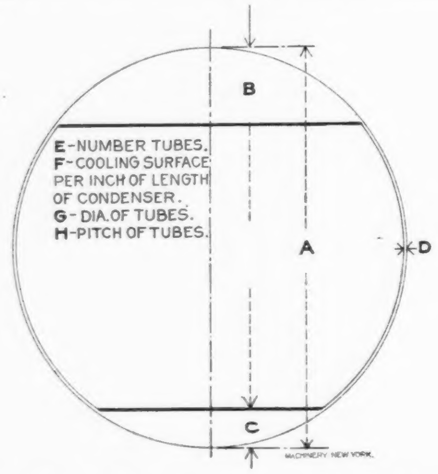
The test tubes shall be weighed together, and this weight taken to represent the average weight of the whole order.

The No. 18 B. W. G. and ⅝ inch outside diameter tubes shall not weigh less than .32 of a pound per linear foot; the No. 19 B. W. G. not less than .28 of a pound per linear foot, and the No. 20 B. W. G. not less than .24 of a pound per linear foot.

The following table was compiled for Foley's Engineers' Book, by Chief Engineer H. P. Norton, U. S. N.

TABLE I.

A.	B.	C.	D.	E.	F.	G.	H.
					sq. ft.		
3′ 0″	7″	3½″	5/16″	987	13.45	⅝″	15/16″
3′ 3″	7½″	4″	"	1146	15.62	"	"
3′ 6″	8″	4″	"	1353	18.44	"	"
3′ 9″	9″	4″	"	1573	21.44	"	"
4′ 0″	9½″	5″	"	1806	24.62	"	"
4′ 3″	1″	4½″	"	2032	27.7	"	"
4′ 6″	11″	5″	"	2258	30.78	"	"
4′ 9″	11½″	6″	"	2512	34.24	"	"
5′ 0″	12¼″	5¾″	"	2805	38.24	"	"
5′ 3″	12¼″	6½″	"	3132	42.69	"	"
5′ 6″	13″	6½″	"	3460	47.16	"	"
5′ 9″	13¾″	6½″	"	3813	51 97	"	"
6′ 0″	14½″	7″	"	4117	56.12	"	"
6′ 3″	15″	7½″	"	4596	61.29	"	"
6′ 6″	15½″	7½″	"	4845	66.02	"	"



Pin test: Each test specimen when cold shall have a taper pin, taper 1½ inches to the foot, driven into it until it expands to ¾ inch outside diameter without splitting.

Cold-bending tests: Each test specimen, cold, shall flatten and bend back on itself without fracture.

Hot-bending tests: Each specimen shall, when at a dull red heat in daylight, flatten and bend back on itself without fracture.

Surface inspection: All tubes must be true to form, of an equal thickness throughout, and have a workmanlike finish, free from injurious cracks and seams.

Tinning: All tubes shall be thoroughly tinned, inside and out, and then given a final drawing to insure their being perfectly smooth inside and out.

Water pressure tests: All tubes after the final drawing shall be subjected to 1,000 pounds internal water pressure without showing weakness or defects.

The shells of the small and medium diameter cylindrical condensers are usually made of sheet brass or muntz metal, and the large ones of steel plate, riveted.

The connections for a condenser include the following: Main exhaust, auxiliary exhaust, hand holes, boiling out nozzle, bleeder pipe, salt feed, soda, air cock, drains circulating water inlet and outlet, air pump suction, hot well discharge, water service, lifting bolts, pump priming, air pump discharge, snifting valve, jet injection, vapor pipe, evaporator pipe, reversing engine exhaust, cylinder drains, separator drains, safety valve, mud holes and sight holes. These connections are not necessarily on every condenser, as it depends to some extent on the type of engine installed, but it would be well to look over the list in designing, to be certain that nothing has been omitted.

To find the condenser pressure: The difference between the vacuum gauge reading and the barometric pressure, divided by two, equals the pressure in condenser in pounds.

In Table 1, is given the data usualy needed in a condenser of circular section.

The computed totals in each case are the number of tubes enclosed in the heavy black lines, in the sketch.

The two middle rows of tubes have been omitted in each computation to allow for horizontal longitudinal diaphragm.

Five-sixteenths inch clearance is allowed betwen tubes and cylindrical shell.

The center of the shell is taken half way between the tubes.

The heavy black lines are outside tangents to the limiting rows of tubes.

The cooling surface in square feet per foot of length of condenser tubes is as follows:

TABLE II.

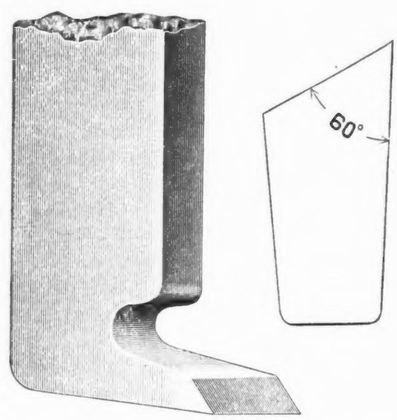
Outside diam. in inches.	0	⅛	¼	⅜	½	⅝	¾	⅞
0		.0327	.0654	.0982	.1309	.1636	.1963	.2291
1	.2618	.2945	.3272	.36	.3927	.4254	.4581	.4909

The next article will continue this subject, dealing more directly with the actual design.

* * *

FINISHING TOOL.

The catalogue of O. S. Walker & Co., Worcester, Mass., manufacturers of magnetic chucks, contains an illustration of a planer finishing tool that they have found valuable and through their courtesy we illustrate it herewith. The peculiarity lies in the angularity of the cutting end, giving a shearing action which prevents in great measure the usual difficulties experienced on the planer in chipping out the edges of the work. The idea is not new, as tools of similar construction are often used, but the improved condition in which such a tool will leave the edges of the work is perhaps not fully appreciated.



Messrs. Walker & Co. say regarding it that "in redressing the top face of our planer chuck, a surface composed of interlocking fingers, with space between filled with softer metal, this tool will be found almost invaluable. It is simply the usual planer finishing tool with the leading face ground at an angle of about 60 degrees. It should be made of steel 1½" by ¾" to insure stiffness, and if kept keen and used intelligently the result will surprise you. Make the bottom as nearly flat as possible and follow approximately the angles shown."

* * *

A decrease in temperature increases the conductivity of metals for the electric current, and in theory a pure metal of the nature of iron or copper would offer no resistance to the passage of a current at the absolute zero of temperature. On the contrary, an increase in temperature increases the conductivity of those substances that are usually regarded as insulators. Glass when heated to near its melting point is an excellent conductor and under the influence of a strong current will glow with a brilliancy approaching that of carbon for a few moments before it dissolves.

NOTES BY A ROVING CONTRIBUTOR.—13.

AN OPINION ABOUT WAVE MOTORS AND CRANK PUMPS—A SINGLE ACTING PUMP WITH A CONTINUOUS FLOW—TWO OTHER NOVEL PUMPS—A WORD ABOUT CRANKS AND THE STUDY OF THE "MECHANICAL POWERS."

San Francisco is the home of the "wave-motor." One comes around, as I am informed, from one to three times a year. The external swell always rolling in here works the wave-motor man into an ecstacy of invention and he persuades an opulent friend to invest in the scheme. I have seen several of the men and one wave-motor. From each of the men I learned that the power was "either the buoyancy of a float or the impulsive action of the water acting throughout a given range." The easiest thing in the world to compute, but there is one factor left out. This I discovered myself and want credit for it. Power is measured by time, or range, and pressure. In wave-motors the pressure and range is all right for the purposes of computation, but as soon as resistance or work is hitched on, the "range" disappears, or is shortened down so this "factor" is cut in two and spoils the equation.

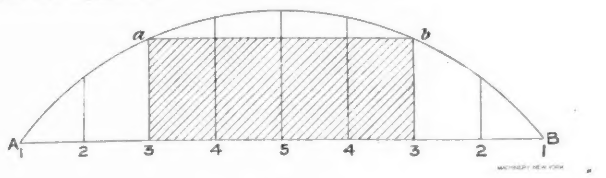


FIG. I.

Suppose, for example, that the curve above from A to B represents the force of a wave, either in buoyancy or impulsive energy and that the ordinates 1 to 5 indicate the force at different periods. Then suppose the resistance to be equal to the force at 3 and the range of action is from *a* to *b*; it is evident that the unshaded portion of the diagram is not work, but is lost. Then cut out from the shaded area 50 per cent. of loss by ramshackle transmitting apparatus, reduce the mean velocity down to 4 feet per second by reason of the intervals and subtract the value of a new machine after each storm and the eco-dynamic value of a wave-motor will appear.

The only sensible one I have ever heard of was invented by some person at Philadelphia many years ago; a level-headed man who proposed to bore a hole in the axis of a pile, drive the pile down into the mud and put a pump in the hole, provide it with a cross head attached by rods at the sides to a circular float that would slide up and down on the pile and thus operate the pump directly. The pump was to send salt water ashore under pressure which could be applied to various useful purposes. Here was a perfect machine, constructively. No machinery to get out of order; no framing except the timber pile and no shore communication except a pipe that could rest in the mud. The man was a genius and at one stroke compassed the whole art of wave power.

Getting More Water out of a Single-Acting than a Double-Acting Pump.

Going along the street one day here in San Francisco, in the district which the people are pleased to call "Tar Flat," I came upon a particulary well made deep-well pump. It was out on the side walk which is included in the shop space and is the erecting shop for most of those small establishments around that district.

The pump was substantial, carefully fitted with various little points, evidently born of experience, so I turned in to inquire into the art and met the man in charge, who was foreman, accountant, one-fourth of the working force and also the owner.

"These pumps," said he, "have to be carefully made. They are sent out into the country and are expected to last for years without being seen or touched. I have just taken one up after twelve years of duty." I asked if they were always made single-acting? "Yes," said he. "We cannot risk the detail of a double-acting pump 100 feet below the surface. We could not get them into the tubes, besides single acting ones raise more water."

Here I was stumped, and looked incredulous, no doubt, for he continued. "If the pipes are about 100 feet long and the speed is right, we get a continuous flow with a single-acting pump because of the straight course and momentum of the ascending water. When we can't do this, we put in a top plunger to displace on the downstroke, but I do not like this for common cases."

A plunger at the top would constitute a bucket plunger pump. That was plain enough, but the other proposition was not so clear. He continued, "I can get more work out of them and have no patterns for double-acting pumps. Quit them long ago."

Further conversation with this man disclosed the fact that he had about as much information, about pumping in a practical way, as Professor Riedler, and knew what the *Indicator Versuche auf Pumpen* had disclosed. He said, "they had large pumps here running at 500 feet per minute before Professor Riedler's inventions."

A "Swiss" Pump.

Less than two blocks away I came upon another novelty, a common pump of the continuous flow pattern, sometimes called a Swiss pump, having two barrels set parallel, close together, with valves in the pistons and none in the pump. The sketch above will explain the scheme. The piston-rods are both strongly fastened in the cross-head and move together. Water flows continually through the pump as indicated by the arrows, with a uniform section or volume, except being contracted where it passes through the bucket pistons. The pumps are double-acting and when driven at a speed corresponding to a certain weight of the water in the pipes produce a continuous flow, or as near that as crank motion will permit.

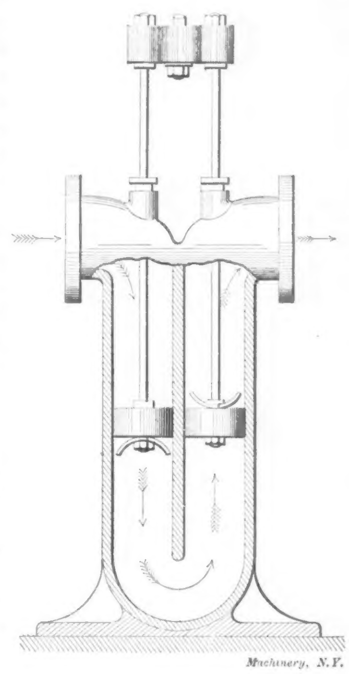


FIG. 2.

Just here let me say about the crank, that perfect and indispensable device for translating rotary into reciprocal movement and the reverse, that it is one of the worst possible contrivances for operating a pump. Its functions are to stop the water absolutely at each stroke, from 200 to 500 times a minute, then gradually set it in motion again and as gradually bring it to rest—a series of jerks it may be called but inferior to a "jerk" because not following up the resistance. Imagine some one raising a load, moving a boat or a train in such a manner! It would be absurd.

Even the twin-barrel pump above is seriously afflicted by crank motion, because the natural movement of the water and of the piston coincide at but one point in the stroke. It is a wonder that any pump can be operated by a crank. An evidence of the imperfection of reciprocating pumps is that their supply and discharge pipes can be one-fourth as large as the pump barrel. Half as large is better, but either case is an indication of the imperfection of the apparatus in its common type and there seems no hope of improvement. Rotary pumps, except the centrifugal type, involve running metalic joints with their surface moving at different rates of speed and are soon inhumed in the scrap pile.

In respect to the double barrel, so called, continuous flow pumps, the idea is not new as many readers will know. Such pumps are made in Switzerland and in France, perhaps elsewhere, but are not common in this country. One impediment is the oblique strain upon the cross-head and piston rods, which is apt to cause unequal wear and fracture of the parts under the high heads or pressures.

A Triple Pump with High Efficiency.

I recently struck upon a novel pump that was in effect, a triple piston single-acting pump which bore the same relation to our Eastern designs that Stephenson's Rocket does to a modern locomotive. It was raising water as I was informed with a loss of 5 per cent. in pump resistance, that is, including friction of machinery and water, which I did not believe until the attendant took off the cover of the crank case, and let me look in. Then

it seemed possible. The machine was of unique design—a kind of rectangular box that in its *tout ensemble* looked like a cooking stove, but as I soon discovered had logic in every feature. The cranks and connections were immersed in a pool of oil and the back of the pistons were flooded with this same lubricant. One side of the pistons were, therefore, exposed to water and the other side to oil. The water entered a vertical valve chamber and came near going straight through the pump. I do not know about the 5 per cent. resistance, but whether five or more, it is by a long difference better than any crank pump I have ever seen in the Eastern States, or anywhere else for that matter. There are scores of these pumps in use here for raising water in buildings that go on for months without the least attention. I am sending an illustration of one.

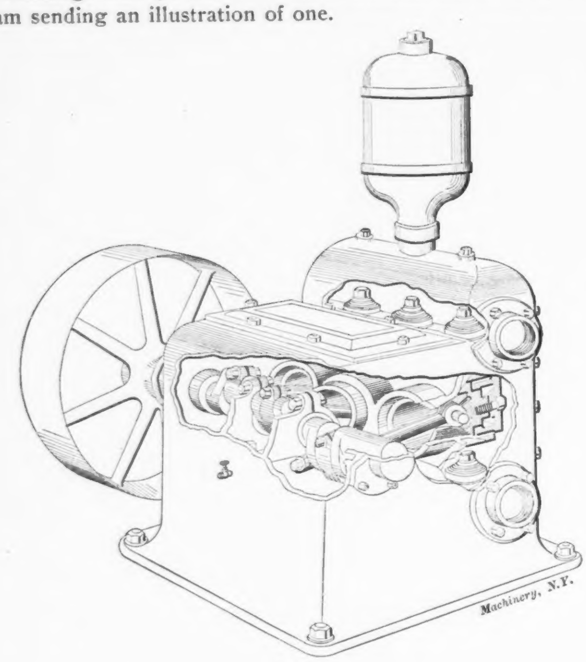


FIG. 3.

These pumps are made by Messrs. W. T. Garratt & Co., of San Francisco, and have given a very high duty. More than 100 are now in use, in many cases for country water works, but principally in buildings, where no skilled attention is provided. They are usually set in a room with an electric motor and visited at intervals by an inspector. They are made of several sizes from 4 inch to 8 inch pistons and when operating are noiseless. The whole machine, as will be seen, is cast in one piece and the design is unique.

The pump "crank" is in evidence here, not the mechanical one above discussed, but the "crank-homo," who finds out how to smuggle water up hill without power. He meets with derision of course, but this only fans his enthusiasm. He knows very well that people are alarmed about their patterns and their business and want to drown his invention. I met one; a quiet, patriarchal looking old chap who had come down from Oregon to introduce a "balanced" pump, two long tubes connected by a beam so as to slide up and down upon two fixed nipples at the bottom of the well. These tubes were full of water, "alike and balanced," he said, so the only force required to pump them was the difference of height in the discharge barrels at the top—a foot or so. He had a structure of the kind, about 20 feet high, tubes of brass, all complete. I had not the heart to argue with him and heard his explanations in sorrow.

Why cannot the simple laws of force and motion be taught in primary schools in such a manner as to take hold of the human mind—a child's mind even? But, I know. Away back I can remember how my class studied natural philosophy and the "mechanical powers," whatever that may mean—a lever, wedge and screw were three of them, just as if these useful devices had some generic properties and performed inherent functions of their own. Of the nature of force which these contrivances were to transmit, we learned nothing. It is different now, let us hope, but when we find one man who carries around with him a conception of the co-relation and conservation of force, there will be ten who know no more about it than a Hottentot does of the fourth dimension. How else could the late lamented Mr. Keeley have thriven for twenty years?

ISOMETRY.

W. H. Booth.

It is now quite a long time since I first advocated the acquisition of a knowledge of the art of isometrical sketching and drawing more especially for showing steam pipe arrangements. Since then others have taken up the subject and I believe quite a number of engineers show steam and other pipes on the isometrical system. Isometrical projection is a modified sort of perspective. In perspective drawing all lines which are really parallel in fact are made to converge to a point. Thus when a cube is drawn in true perspective so as to convey to the eye an impression of a cube, what is really shown is part of the thick end of a pyramid. Thus in Fig. 1, we have approximately a true perspective view of a long pyramid. In this picture, had I drawn it correctly, an impression is given to the eye which enables the eye to form a correct idea of a pyramid. I draw the two dotted lines cutting off part of the thick end and the figure thus cut off is the perspective view of a cube. Now in a cube every angle is a right angle. In this perspective cube there is no right angle. From some points of view one angle might be a right angle. Give this drawing to a mechanic to make a cube from, and he could not do it by scaling off the dimensions for these are all wrong. Now in isometrical projection dimensions can be scaled off. In Fig. 2, we draw a square a, b, c, d, to represent one side of a cube. By adding other five lines we obtain an approximate perspective view of the cube and we can measure the cube from its one correctly drawn side. Three of the edges are produced as shown dotted so that *be* correctly scales off the true dimension. Now *be* appears very much longer than *ab*. Yet *ab*, *be* and *ef* are all one length. This shows that our eyes cannot appreciate lengths and it proves to us that what our eyes really convey to our brain is merely the projection on a plane of everything in their line of vision. Experience alone teaches our brains to

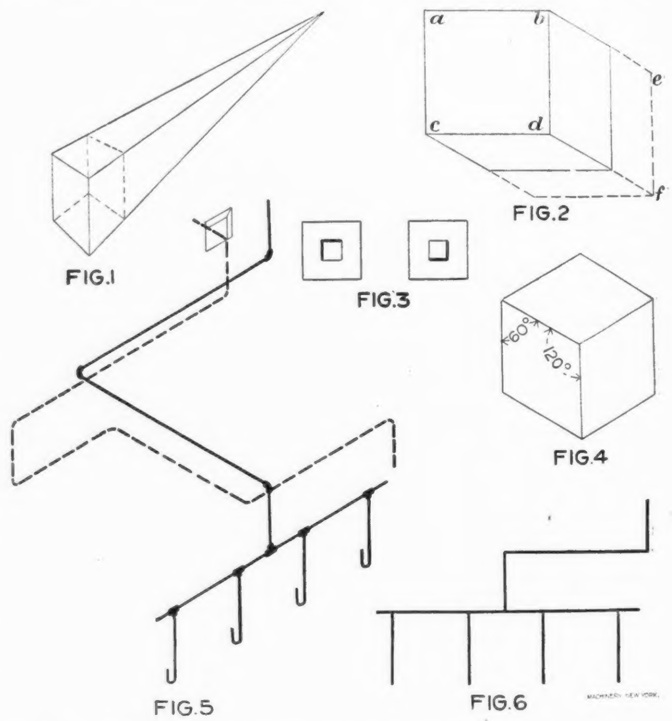


FIG. 1 FIG. 2 FIG. 3 FIG. 4 FIG. 5 FIG. 6

translate what the eye shows into a picture of reality. Thus a blind man who may think he knows all about a circle and a triangle cannot, if restored to sight, tell one from the other without handling them. The uniform outline of one and the three angles of the other do not at first convey any idea to his untutored eye. Even our practiced eyes are apt to read the full lines of Fig. 2, not as a cube but as the far inside corner of three sides of a box. The corner *d* may appear either near the eye or far from it. Hence the employment of shading to convey ideas more plainly. Shading assists to destroy ambiguity of impression. Thus, in Fig. 3, the two employments of two thick lines convey respectively the idea of a square hole in a flat surface or a cubical projection upon a flat surface. In isometrical projection it does not matter to us that things look wrong to our eyes so long as we can correctly measure off their sizes. In machinery and in engineering generally we use right angles to the exclusion of almost

all other angles, and where such other angles are employed they are usually very obvious and known, and it is only in the fact that the angles are not shown correctly that isometrical projection is not capable of being scaled off. In Fig. 4, we have a true isometrical projection of a cube. In isometrical projection as in true perspective all vertical lines remain vertical and all horizontal lines are made to slope up to the right or left according as they lie right across the line of vision in a plan view or in the line e according as they lie in the plane of the paper or appear on the paper as points. Thus all right angles either appear as angles of $90° + 30°$ or $90° - 30°$ or $120°$ and $60°$. Circles of course become ellipses and are more troublesome to deal with. But it is not for general work that isometry is best employed though occasionally it is helpful. It is in pipework and similar work that it is most useful. We all know how troublesome pipes are to show—how in getting out the numbers of valves, tees, elbows and bends we are apt to miss out perhaps a whole length of pipe simply because of the small showing which a hundred feet of pipe makes in end view. In showing pipes isometrically we see in one picture every line of pipe no matter in which of the three co-ordinate planes it may lie. Thus in Fig. 5, we see a pipe which descends a wall vertically is carried horizontally along the wall some distance and then advances directly towards us to the front of say the front wall of a range of boilers. It drops a few feet and then joins a long horizontal pipe from which descend four vertical pipes to each of four boilers. These same pipes are shown in elevation in Fig. 6. It is plain that Fig. 5 is the most easy to read and that the details of junction pieces are easier to make out. But suppose there were two pipes parallel to each other in parts only. The ordinary three views of a drawing would be most misleading. The dotted line in Fig. 5 plainly shows up every direction and dimension of a second pipe which comes through a square opening in the back wall. This system is easy to acquire. The ordinary $60° - 30°$ set square can be used on drawings but the chief advantage is on outside sketching and dimensioning, and when practicing I have found the method most useful in showing quite a multiplicity of pipes. In sketching absolute accuracy of the angles is not necessary.

* * *

WHAT WOULD YOU DO IF YOU WERE THE BOSS?

BEEN THERE.

Once upon a time—and not long ago—there was a young man who had been working in the shop, but having an idea that a draftsman was a little more high-toned than a machinist, had managed to get "promoted" (?) to the drawing room. To do him justice it should be said that he got along in the drawing room very well, indeed, but being quite a young man it wasn't long after he got into the drawing room before he had to add to his set of instruments a shoe horn to assist in putting on his hat.

Then he got to thinking that a draftsman ought not to get up quite so early in the morning (but he wanted his "time" to "go on" all the same), and for some reason this didn't seem to please the Boss.

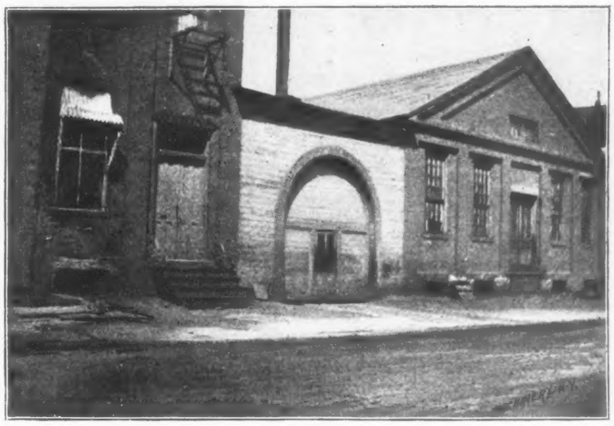
Now, the Boss had his weaknesses also, but lying* abed in the morning wasn't one of them; in fact he was always the first man around the shop in the morning, and one of his worst enemies said, unsolicited, that the Boss "was always an early bird, anyhow."

To come back to the weaknesses of the Boss, one of them was trying to encourage (?) apprentice boys, draftsmen, etc., etc., to be early birds also by telling them what HE used to do when HE was an apprentice boy, and so apt are bosses, as well as the rest of us, to judge others by ourselves, that this particular boss actually had an idea that any man who wasn't a combination of early bird and first-class machinist might as well give up his pew.

So it happened that after the young man had sneaked in late a few times the Boss kicked, and as that didn't have any favorable result, the Boss sprung his favorite tale of when HE was a boy HE used to be so anxious to go to work that HE used to get down to the shop so early in the morning that the big front gate would not be open, and he would therefore climb over it and get into the shop, and go to work, "and now I am Boss," etc., etc.

* The reader can judge for himself whether the boss had a weakness for any other kind of lying.

As this is a true story I have taken a photograph of the gate, and the editor has obligingly had a cut made from it, from which the reader will see that the Boss in his younger days was better than a green hand on climbing, as well as in ambition to be an "early bird."

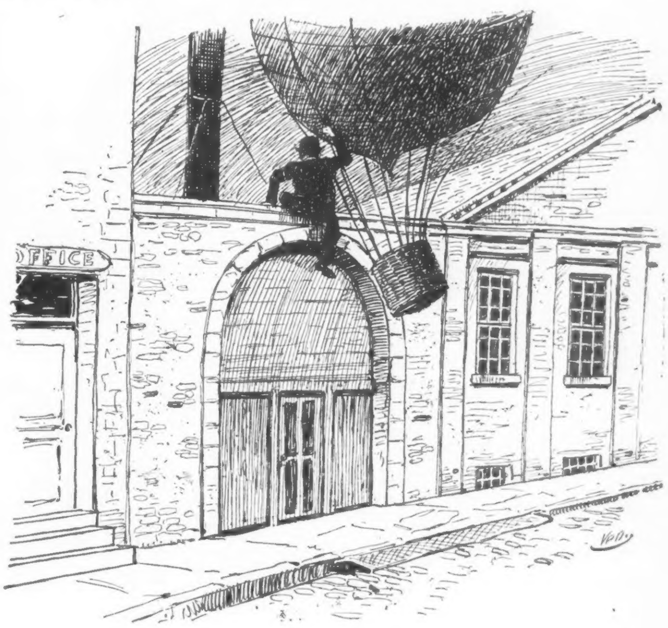


THE GATE

The next morning, after he had told the young draftsman about his (the Boss's) early gymnastics, he (the Boss) went in first thing to see the young draftsman, supposing, of course, that the gate climbing story would have its usual effect. But the young draftsman wasn't in, and this hurt the Boss's vanity, because this gate treatment had never before been known to fail, and the Boss made a few remarks which are not considered proper except when uttered by a regularly licensed preacher. The Boss waited a few minutes, expecting that "every minute would be the next" and that the draftsman would surely come earlier than he had been in the habit of coming in, anyhow, even though he wasn't on exact time.

But the young man failed to appear, and the Boss finally lifted up the corner of the cover of the drawing board and saw the edge of a blue print. "Oh, ho," said the Boss, "even if he isn't in this morning, he hustled around and got that job done last night, so my talk did some good, anyhow; I don't see how he managed to get that done and get a blue print in such a short time, but he CAN hustle when he has a mind to."

So he lifted the cover away off to see the blue print of the job he was in a hurry for, and the second cut shows what he found on the blue print.



THE BLUE PRINT.

What did the Boss do when the draftsman came in? Well, with what you know of that gate, judging from the picture, and as the draftsman was really a pretty good draftsman, and as in consequence of the present lively state of business good draftsmen are none too plenty, what would you have done if you were the Boss?

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AUGUST, 1899.

CIRCULATION STATEMENT.

The regular edition of MACHINERY for August is 17,150 copies, AMERICAN MACHINERY is the title of the foreign edition, printed on thin paper and comprising all the reading and advertising matter in the domestic edition. No subscriber is entered on our mailing list until his subscription is paid for, and all subscriptions are stopped at expiration. No papers are sent free except to advertisers, exchanges and circulation agents

The circulation of the three leading papers in the machinery trade, so far as it is possible to obtain the figures, is as follows:

The IRON AGE, about	7,000
The AMERICAN MACHINIST, about	12,000
MACHINERY	17,150

CRITICISM IN THE SHOP.

If there is a machine shop in the land where the management, from the treasurer down, is not subjected to more or less criticism among the employees, we have not heard of it. It is in human nature to think "how I would run the shop" or "what I would do in his place" and these opinions are pretty freely expressed around the machine shop, especially by those who are affected by some order in a way they do not like.

Criticism in itself is not a bad thing, although we have known those who apparently thought so, or at least, did not like it. On the contrary, the more thoughtful and intelligent a man becomes the more will he see to criticise because his ideal will be higher and he will be less contented with things as he finds them. If it were not so there could be no advancement in the world. Criticism is the best medium the teacher has at his command for the instruction of his pupils and it is a stepping stone for progress everywhere.

Judged in this light, the machine shop should be a prolific field for progress and advancement—and we believe it may be. There is no class of men who are more level-headed and competent to express opinions than intelligent, well-trained machinists. The very nature of their trade is such that it requires thought and study to an unusual extent and the work is often of such a character that it affords plenty of time for thinking on the part of the mechanic.

The bad feature about criticism in the shop is not that it exists there, for we consider this to be a very favorable sign. The trouble is that it is seldom given where it will do any good or in a way that will do any good and with a full knowledge that if it were so given it would not be received in the most amiable spirit. It is also given, in most cases, with but a partial knowledge of the facts and criticism, based upon half knowledge, is one of the most wicked agents that can be at work.

The remedy for these harmful features is not to attempt to discourage criticism, but rather to court it; to afford the opportunity for it to be given where it will do some good and try to have such mutual good feeling all around that it will be given in a way that will do some good. We are aware that this is a hard matter to bring about. Few men have the strength of character to stand up to the mark and tell another exactly what they think; fewer still have the faculty of doing this in a nice way and a kindly spirit; and there are few indeed who are disposed to accept such expressions with a feeling of thankfulness.

There are good and sufficient reasons, however, why every shop should be dominated by such methods to as great an extent as possible. We will assume that in the average shop there are twenty-five men at work to every one in authority. At least some of these men have capable brains, and taken all together they probably do from ten to twenty-five times as much thinking as the single one who is over them. They are probably able to evolve about ten times as many ideas as this one, and if there is an undercurrent of dissatisfaction in the shop he will probably be beaten in the long run by about twenty-five to one. It is for the interest of the management, therefore, to have the relations between the foreman and the mechanics, and the superintendent and foreman, so cordial that criticisms and suggestions will be freely given and well received.

It is astonishing at times, to trace back a course of events and and find how wide dissensions and bitter feelings have arisen from trivial causes. Better far to nip these in the bud than to allow a forced rupture to occur and the best way to do this is to have it understood that criticisms are invited. There is nothing like a full and free understanding at all stages of the game.

Again, when a shop is in business to make money, it is better for employer and employees to pull together and fight the fellows outside than to fight among themselves—provided there is any fighting to be done. A concern can exist with external quarrels, but not with internal ones and here also a mutual understanding and free criticism may nip the trouble in the bud.

It may be advanced that it is all very well to talk about obtaining criticisms in the shop, but that the plan is not feasible. Perhaps it is not. If the general policy is in this direction, however, a great point will be gained. The most conspicuous example of an attempt in this direction is that of the National Cash Register Co., Dayton, O., where special efforts are made to obtain criticisms or suggestions from every one, and we understand that their method is not entirely successful. Much can be done in any shop by a little tact on the part of the foremen through conversation with those under them, and provided a similar disposition is shown toward the foremen by their superiors.

On the part of the mechanic it should be remembered that unjust criticism is not a step to advancement. Criticism behind the back which could not be defended face to face, can do no one any good. Those who hold the upper positions must be given the credit of a reasonable amount of intelligence and unless there is sufficient ground on which to base an honest judgment, fault finding is bad practice to indulge in. A man with a full knowledge of the facts in all their bearings will often act in a way that is entirely opposed to the ideas of one who lacks this knowledge.

* * *

The less red tape used in the management of a machine shop the better, within reasonable limits. Some concerns, apparently, are close imitators of the United States army in this regard, while others have everything going at loose ends. There should be enough red tape so that all orders will be given to the foremen and not to the individual workmen and also so that changes and alterations will go through the drawing room first and not take effect through changes on the drawings in the shop or by a verbal order in the pattern shop, leaving the drawing room to find out about it later.

AMONG THE SHOPS.

NOTES FROM NEWARK SHOPS—THE MANUFACTURE OF THE HYATT ROLLER BEARINGS—STONE PLANERS—WOOL CLEANING MACHINERY—TURNING CRANKS.

Undoubtedly one of the great improvements in the manufacture of modern machinery, has resulted from the introduction wherever possible and practical, of anti-friction bearings. The improvements in the design and manufacture of roller bearings have been carried to such an extent that it would be somewhat difficult to name many places in which they have not been tried and found satisfactory. The latter statement applies very well to the product of the Hyatt Roller Bearing Company, which is located at Harrison, N. J. (a suburb of Newark), as the writer who recently made a call at this interesting shop found from an inspection of their plant. A description of this style of bearing is scarcely necessary as it is quite familiar to most mechanics

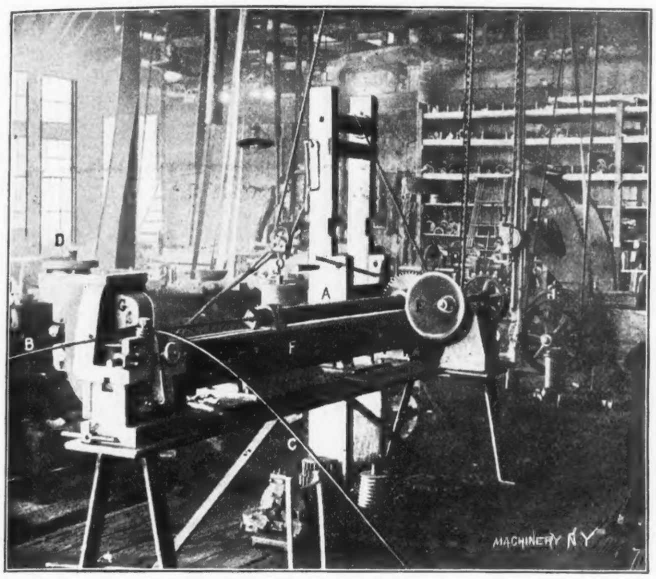


FIG. 1. ROLL COILING MACHINE.

either by personal experience or through the extensive advertising which it has received. Without going into details, however, it may be stated that it is a roller bearing in which the rollers are flexible by reason of their peculiar construction, being helices of steel wound upon a mandrel in a machine specially constructed for this purpose. The mandrel being removed after the completion of the rolling process, a hollow helical cylinder is left which is capable of sustaining a heavy load without permanent deformation and which has the desirable feature of adjustability to the irregularities of the shaft and box. As this form of bearing was primarily intended for shaft hangers, it will be seen the feature is of considerable importance as it is practically impossible to get and keep line shafting in perfect alignment, but by reason of the flexibility referred to, the Hyatt bearing is said to retain its anti-friction qualities under quite adverse circumstances.

The machine for rolling the helices, shown in Fig. 1, has for its principal feature a rotating screw A, which is driven by a chain belt through the gearing shown. The ribbon of steel C is wound upon the drill rod mandrel B and passes under the rollers in the jaw G, which are capable of exerting a heavy pressure upon the forming helix. Any one who has ever seen the finished rollers has undoubtedly admired their finish and accuracy but with the exception of some rollers intended for quite high grade work like motor carriages, calendar rolls, etc., there is no further operation upon them aside from the cutting off and smoothing the ends, after leaving this simple and comparatively inexpensive machine. The torsion of the drive in rolling the steel strip is taken by the helix itself, the mandrel merely acting as a former and sustaining the pressure of the rollers. It will be seen that the machine turns out a cold-rolled product of varying degrees of hardness according to the quality of steel used in the manufacture. The writer was informed that rollers are made from steel containing carbon as high as one-half of one per cent.

After the rollers are wound they are cut off in the smaller sizes by band saws similar to those used for sawing wood, but those made of the higher grades of steel are necessarily cut in a lathe. Some of the rollers intended for very heavy service are wound upon a steel mandrel which is left in the roller and thus makes practically a solid roller but one still preserving a certain degree of flexibility. As intimated previously some of the rollers used on high grade work are ground in a grinding machine as are also the shells for the boxes. The latter grinding is done upon a lathe rigged for the purpose and connected with this subject the overhead drum may be briefly described. As is well known a drum of any size and length for overhead work is usually a heavy and somewhat costly concern, but the one used here and built under the direction of Mr. Woodruff, the superintendent, is worthy of mention on account of its simplicity, cheapness and lightness. It consists of three ordinary split wooden pulleys of four or five inch face mounted on a shaft at a distance of about twenty inches apart with a sheet of heavy galvanized sheet iron rolled to the proper diameter and nailed to the faces of the

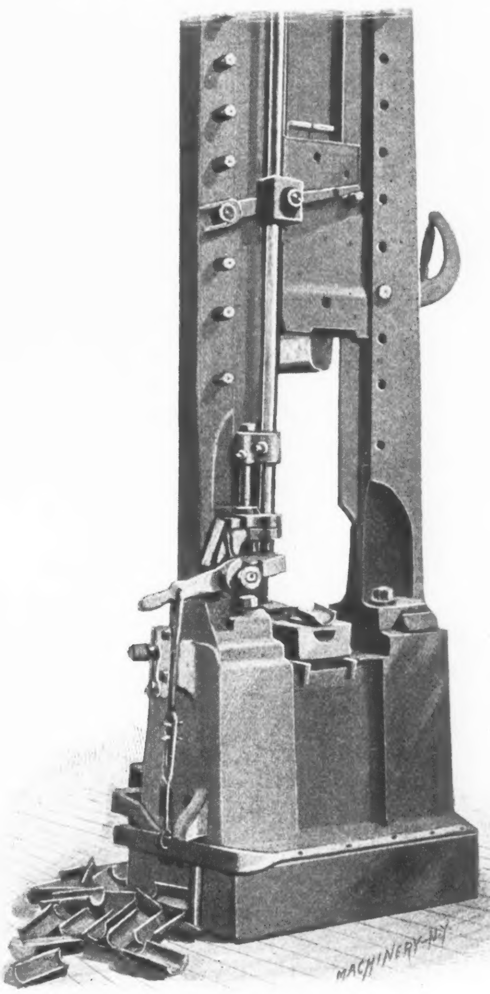


FIG. 2. DROP FORGING THE SHELLS

pulleys. The longitudinal seam is riveted and possibly soldered together. This drum has been in service for some time giving perfect satisfaction.

The semi-circular shells for the ordinary bearings are formed from sheet steel which in the case of the larger sizes is rolled to about the proper shape and then heated in a furnace and formed in a hydraulic press to the required radius. A Billings & Spencer 600-pound drop hammer has recently been installed for the forming of the smaller sizes and a view of it is given in Fig. 2, showing the dies and some formed shells. It will be noted that the ends of the shells are turned up which is necessary to prevent the rollers from working out endways which is their invariable tendency on account of the helical shape. When

used on shafts that require to be free from end thrust it is found necessary to make one-half the rollers with a right-hand twist and the other one-half with a left-hand twist so that the thrust will be balanced. Of course the thrust is slight and it is not usually necessary to provide for it in this manner.

While the business of this company has attained quite extensive proportions, they have declined to enlarge their shops while it is possible to hand e the business in the present quarters, and to increase the product, machines are instal ed that are capable of a wide range of work. A McCabe lathe is in evidence and is said to be one of their most useful tools on account of the range and the fact that only a small proportion of the work requires the extreme swing so that the cost of an ordinary lathe of sufficient capacity for the largest work would be a poor investment. A recent addition to the shop equipment is a Prentiss turret lathe, with a turret tool holder which m kes it a useful tool for boring and turning the steel shells simultaneously.

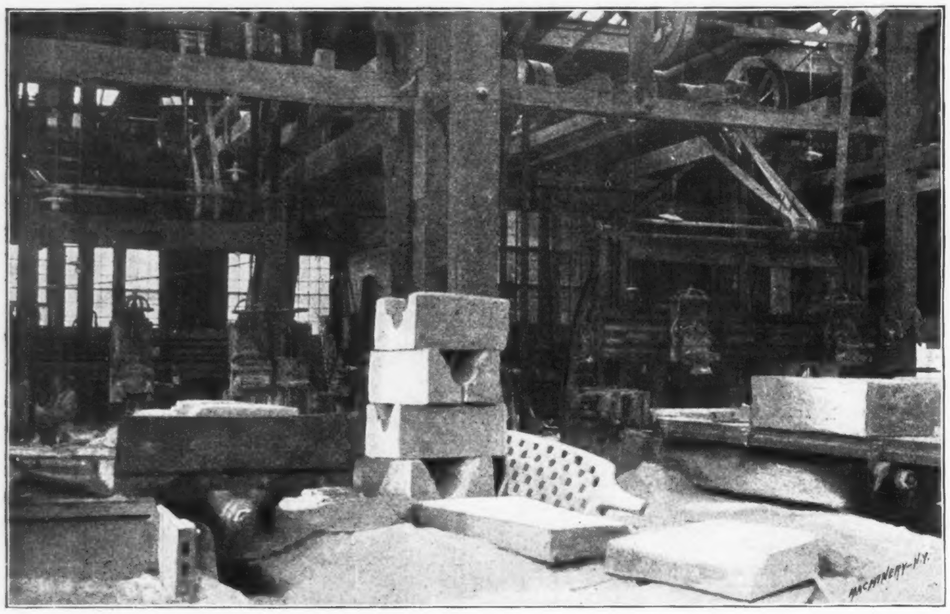


FIG. 3. PLANERS IN A STONE WORKING SHOP.

The writer was informed that the company have manufactured the Hyatt roller bearings in sizes ranging from an eighteen inch shaft with rollers one and one-ha f inches in diameter down to a one-half inch shaft with rollers one-eighth of an inch in diameter.

Stone Working Machinery.

Newark seems to be a center for the manufacture of building stone into the various shapes and ornamental designs that are required in modern architecture. There are said to be nine shops devoted to this business and a number of them are of considerable size, one of which is that of J. J. Spurr & Sons, where four planers can be seen at work surfacing off Indiana limestone with a reckless abandon that nearly makes an ordinary mechanic's hair stand on end. The planers used appear to be buiit on substantially the same lines as the more ordinary iron planer, but do not usually have the feature of automatic feed, as this would be a superfluous luxury.

Two of the planers are shown in Fig. 3, the one on the right being double, as there are two platens. On ordinary work two men work on this machine, one on each side; but when large blocks of stone are to be surfaced, the two platens are driven together by throwing the driving gear into the proper position. All the machines in this shop are of the screw type, but the screw is arranged longitudinally with the platen and not at an angle, as in the Sellers type. The machine at the left is arranged with a radius attachment so that arcs of a circle can be planed. As the photograph does not show this feature distinctly, the sketch Fig. 4 is given which shows the essential features. The block of stone is laid upon the part marked A, which is pivoted at the further end and oscillates on the piece H. The piece D is screwed fast to the platen and has a channel in its under side in which the bar B can slide. This bar carries two rollers, one being shown at C and the other is covered by D being in the channel in the piece E. The reciprocating action of the planer gives B a transverse movement, the amount of which depends on the angularity of E. Circles planed with such a rig approximate an arc of a circle near enough for all practical purposes when the proportion of the length of the arc is small as compared to the circumference of the circle. The form of tool post is shown at P in the same figure, while some of the tools are shown in the group photograph Fig. 5. These tools are large and heavy with an enormous width of face in some cases as compared with ordinary planer tools, the one on the right having a width of about fourteen inches. As will be noted the use of forming tools is very much in evidence, being used on the ogees and for rounding corners. Probably most machinists would rather scorn the idea of running one of the machines, but the skill and dexterity shown by some of the operators is quite remarkable. A block of stone is laid on the planer by a traveling crane and in a very short time it is fastened to the platen. Three or four cuts with a feed of nearly a foot in width finishes the top and then the same operation on the bottom leaves the block in condition for finishing the edges. When all four edges are to be finished in some rather complicated fancy shape it is evident that considerable skill is required to have all the corners register exactly alike, but it is done and done rapidly. Empty nail kegs and cushioned chairs for the enjoyment of a "loaf" are an unknown quantity.

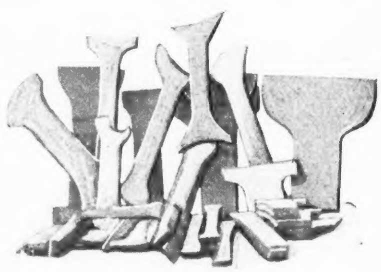
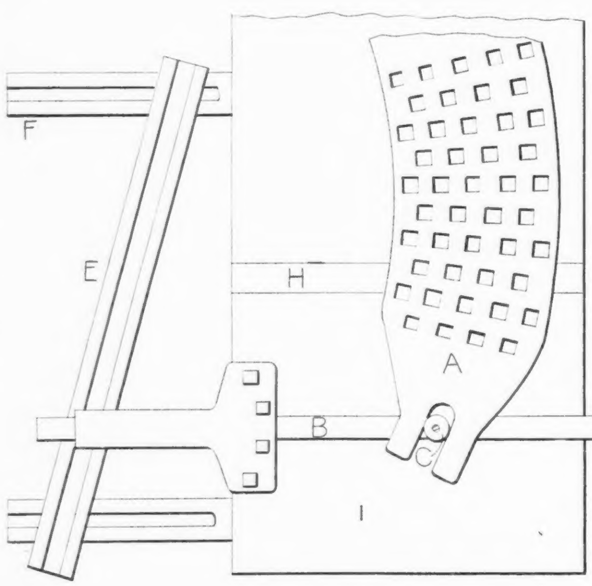


FIG. 5.



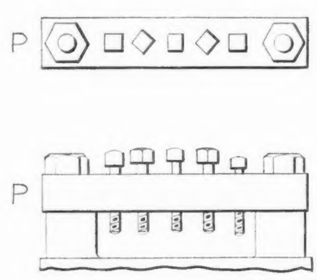


FIG. 4.

Wool Cleaning Machinery.

A call at the shop of the Atlas Manufacturing Company resulted in some interesting "kinks," a few of which are given here. The machines made here are for the cleaning of wool as it comes from the sheep's back and preparing it for the carders. The interesting fact was learned that ordinary wool shrinks 50 per cent. in weight in the cleansing process and some grades as much as 68 per cent. While this is not strictly an item of mechanical information, it may serve to clear up some of the evident discrepancy between the price of wool and the suit of clothes made from it.

An interesting scheme was seen for balancing the cylinders that form an important part of the wool cleaning machines. A cylinder four feet long, twenty inches in diameter and running at a speed of one thousand rotations per minute requires to be very balancing weights. When the cylinder is run at speed the end that is out of balance will throw out and is marked with chalk the same as is done in chucking a piece of work in the lathe. The cylinder is then stopped and the disc on that side shifted around until a bolt hole comes opposite the chalk mark. A piece is then fastened to the disc of the appropriate weight as near as can be guessed and then the operation is repeated. If the next trial shows that the other end throws out, a piece is fastened to the disc on that end in the same manner. When after repeated trials the proper weights have been attached to the discs so that the cylinder runs smoothly, pieces are made of the same weight and of appropriate shape which are fastened on the cylinder directly opposite their positions on the discs. When swiftly revolving cylinders are balanced in this manner no trouble need be apprehended from vibration.

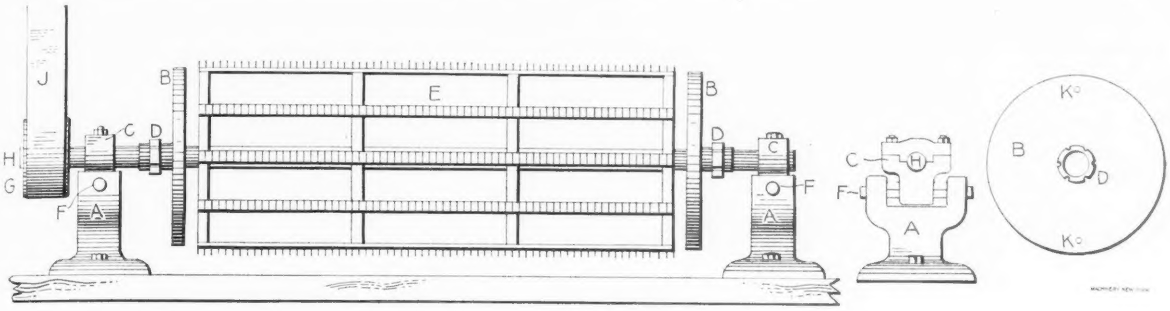


FIG. 6.

accurately balanced to admit of its being successfully run in these machines. It is well known that a cylinder of this length may be balanced with the greatest care on balancing ways and still vibrate excessively at high speeds. The cause of this is that while the cylinder may be in balance, it is not symmetrically balanced. Thus, if a machinist is balancing a cylinder and it shows the need of a certain weight opposite the heavy side, how is he to know

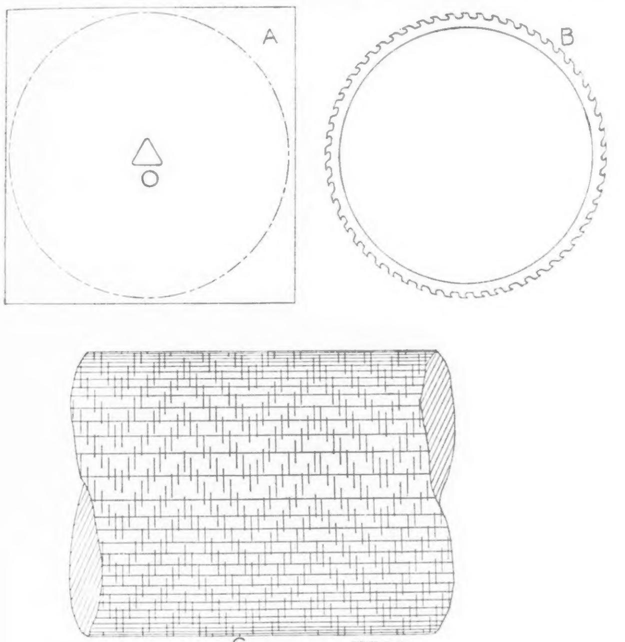


FIG. 7.

at which end to put it? If it be put at the wrong end, the cylinder may appear to be in perfect balance but it will surely vibrate when run at high speeds. To obviate this difficulty the foreman of the shop has arranged the interesting device shown in Fig. 6, and the cylinders are tested in it at top speed before they are allowed to enter the machine. The cylinder E, mounted on its shaft H, is placed in position in the boxes C, C, which are loosely mounted on the pillow blocks A, A. As will be seen from the end view they have freedom sideways and are also given some space for vertical movement. The discs B, B, are turned all over and perfectly balanced and have tapered split sleeves over which screw the taper nuts D, D.

As the bore of the sleeves is a close fit on the shaft the disc can be quickly clamped to it in any required position. Two holes, K, K, are drilled near the edge of the disc for the fastening of the

Many of the picker cylinders used in the wool cleaning machines require an immense number of hook-shaped teeth and the method in which they are made is deemed of sufficient interest to be presented. The cylinder is made up of three or four narrow cast-iron discs mounted at intervals on the shaft and which are covered with a casing of two thicknesses of sheet iron, thus forming a smooth drum.

After this drum has been made as smooth and accurate as possible by grinding, it is covered with toothed rings of crucible steel like B, Fig. 7. These are arranged in various orders but the form shown at C seems to be quite common and it becomes evident from an inspection of this design that it is necessary that the tooth spacing should be extremely accurate as a very small variation in the spacing destroys the regularity of the V's. As the diameters of these cylinders are graded, the practice is followed of "stepping down" the discs. That is, the center of one ring is made to produce a ring for the next size required. This involves some method of making the punchings concentric with the periphery and it is accomplished very neatly by first punching the triangular hole O in the sheet. The punches for all the different sized rings have circular steel centers that enter this hole and center it accurately with the periphery of the punch.

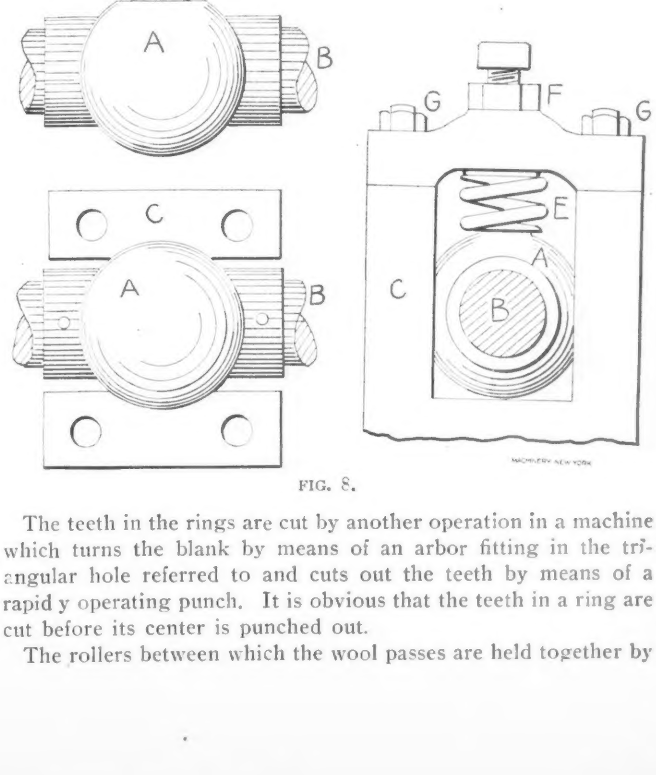


FIG. 8.

The teeth in the rings are cut by another operation in a machine which turns the blank by means of an arbor fitting in the triangular hole referred to and cuts out the teeth by means of a rapidly operating punch. It is obvious that the teeth in a ring are cut before its center is punched out.

The rollers between which the wool passes are held together by

springs as allowance has to be made for the passage of foreign substances that may be present. They must also be arranged so that one end can raise without disturbing the relation of the shaft to its box or in other words so there will be no cramping or binding of the journals. The box A, in Fig. 8, has a spherical part and projecting from each end are two bosses which serve to give length to the bearing. The frame of the machine at the position for each box has two jaws which are bored out on the drill-press to the diameter of the spherical part. It will be seen that with this arrangement the box is free to turn in any direction without interference within limits and it can also lift to clear obstructions. It is only restrained from a direct lateral movement, which of course is never required.

Some interesting problems in varying ratios of speed are presented in this class of machinery as it is necessary to remove the wool which is engaged in the hooks of one cylinder by the teeth of another which is traveling in the same direction but at a somewhat greater peripheral speed, although possibly it may be of smaller diameter.

Turning a Four-throw Crank.

The turning of a single cranked shaft is a more or less troublesome job according to the apparatus at hand for handling it, but, when the number of cranks is increased to four with a comparatively long and slender shaft, it is evident that something out of the ordinary must be provided to enable the job to be done satisfactorily. The New Jersey Machine Works have recently been building a number of vapor engines which have eight cylinders, but arranged in pairs tandem fashion, so that only four cranks are required on the shafts.

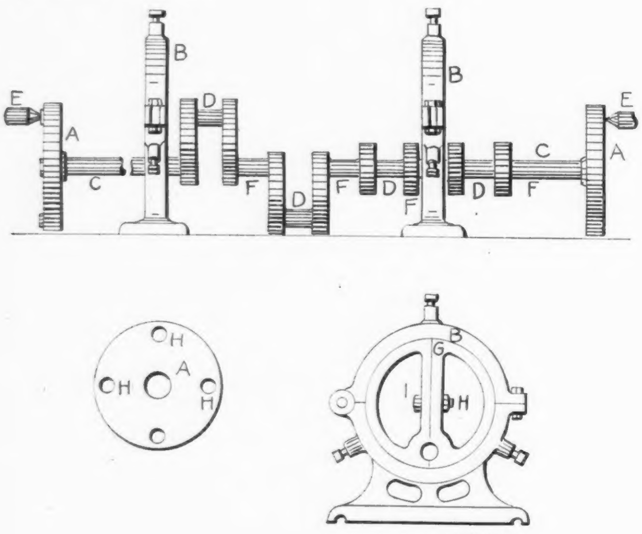


FIG. 9.

The method for turning the crank shafts, while not new will undoubtedly be of interest to many readers and is shown by the various sketches in Fig. 9. The steady-rests B, B, were bored out for the eccentrics, one of which is shown at G. These eccentrics are split, the one shown, being held together by the bolt I, and the distance from the center to the shaft C is one-half the stroke of the piston. The discs A, A, each have four steel centers H, H, H, H, which are accurately located at the four equal division points of a circle and the discs are fastened on the shaft for turning so that each one of the centers will coincide with the axis of one of the pins. The function of the steady-rests with their eccentric discs is perfectly apparent as it is possible to locate a steady-rest close to each side of a crank, or bearing being turned and operate on it with a minimum of chatter and danger of accident. The only precaution to be taken in setting the eccentrics for turning either the crank-pins D, D, D, D, or the bearings F, F, F, F, F, is to get the center I perfectly in line with the axis of the part being turned. When the discs A, A, at the ends have been accurately located, the eccentrics with a little manipulation will adjust themselves in their proper position when they can be tightened on the shaft. As shown in the sketch, the crank-pin D next to the left steady-rest is the one being turned, as its axis coincides with that of the lathe centers.

* * *

Adapt the hammer and chisel to the work in hand and do not attempt to chip a light fragil casting with a two-pound hammer and a chisel made from a $\frac{7}{8}''$ bar.

EDUCATION IN CHINA.

Prof. F. F. Crocker is contributing some interesting notes upon China and the Chinese to the *Electrical World*, in which he treats mostly upon engineering "as she is engineered" in that country, particularly the electrical branch of it. The following extract shows the status of advanced education in that country and is an example of the indescribably antiquated methods and powerful prejudices that must be overcome before any marked advance is made in that far off land. If it be true that education is the key to advancement, civilized nations have a stupendous task before them in reclaiming China and making it a market for their products.

Electrical education in China, like most of the other electrical matters tnere does exist, but unlike them, it is not likely to be developed for many years to come. It is already well advanced in Japan, because that country is very progressive, while China is about as much so as a dead turtle. To be sure, the general educational system of China is extremely elaborate, but it remains the same as it has been for centuries. The Chinese "Book of Rites," dating from 1200 B. C., which is thirty-one hundred years ago, says: "For the purpose of education among the ancients, villages had their schools, districts, their academies, departments their colleges and principalities, their universities." This system is as complete as anything to-day even in Germany, and antedates by two thousand years the oldest universities of Europe. But little progress has been made since that time. It is still almost confined to Chinese classics (Confucius and other early writers) and history. Mathematics and science are not taught, and the history, geography and other facts concerning any nation but China are unheard of. Beyond the ordinary education there are three degrees which are given to those who successfully pass advanced examinations.

The first of these degrees, called Siu-tsai, and meaning "flowering talent," is somewhat equivalent to our B. A. The candidate must undergo three examinations, the first being held in the local districts, the second in the chief town of the department, and the third in the capital of the province. The percentage of successful ones who finally graduate is small. The second degree is known as Ku-jin (variously spelt), signifying "promoted men" and corresponding to our M. A., for which examinations are held triennially in the provincial capitals before two Imperial Commissioners, being simultaneous in all the eighteen provinces. Many of the candidates are of middle age, and some are sixty or seventy years old, the average age being over thirty. Cases have occurred where father, son and grandson have competed at the same examination. The number of students is very large since all of the siu-tsai or holders of the first degree in the entire province are included. At Canton, the capital of the province of Kwang-tung, having an estimated population of thirty million, I visited the "Examination Hall." This expression hardly gives one a correct idea, as it is really a very large enclosed space about 1,400 by 650 feet divided into two sections, for officials and candidates respectively. The accommodations for the latter consist of a great many rows of cells on either side of a wide avenue. Each cell is 5½ by 3½ feet, the total number being 11,616. In these the candidates are individually confined at daylight, the same texts being given to all upon which original essays must be written and handed in by the following morning. Careful watch is kept by the authorities to prevent inter-communication. The examinations occupy three sessions of three days each. Out of the many thousands who subject themselves to this ordeal only about one hundred obtain the degree. These are then eligible to go to Pekin to attempt the third or doctor's degree, for which the procedure is similar, but the examiners are of higher rank. In this trial only about two or three hundred of the candidates from the whole empire finally succeed, and enjoy the honor of being introduced to the Emperor, provided the Dowager Empress is willing and has not poisoned him beforehand.

From among the graduates or survivors of this process various civil offices are filled, such as that of magistrate, etc. But many of the holders of degrees never secure any official position, owing to favoritism, the possibility of purchasing degrees and other "ways that are dark" for which the "heathen Chinee" is justly celebrated.

* * *

Spare no pains to make the joints of an injector perfectly tight and never use gaskets of any description if it be possible to make perfect joints without them.

LETTERS UPON PRACTICAL SUBJECTS.

ABOUT THE LOW TAIL-STOCK AGAIN.

Editor MACHINERY:

Having been connected for some years with a jobbing shop which is sometimes called an "india rubber" shop on account of its capability for taking in any job and afterwards finding some way for doing it, it has been my fate or fortune to deal with lathes in various stages of worn out condition. A shop of the class mentioned almost always has machines that are old and nearly worn out, but the results turned out are usually "good enough" for all ordinary purposes. In connection with this, the letter written by Mr. J. R., and published in the June issue of MACHINERY was of interest and I can indorse what is said in the following editorial comment, "that the point brought out by 'J. R.' is worthy of careful consideration," but I think that this gentleman is blaming the manufacturers for a fault that is caused by "Father Time" and rough usage. To begin with if Mr. J. R. would carefully examine various makes of new lathes and also some old ones, he would find the centers of the new lathes in practically perfect line; whereas, the dead centers of the old ones will usually be found to be considerably lower than the live centers. This defect is caused by wear from sliding the footstock backwards and forwards over the ways when covered with gritty substances and when minus any lubricants. The continual clamping strain also tends to lower it and in two-thirds of the lathes now being built we will find that the spindle clamping device in the footstock is effected by splitting the casting and clamping the top half down against the spindle, so naturally if any wear takes place the tail-spindle is again lowered. The conditions in the live spindle bearing are different, as this is usually kept well oiled, so there is but little wear, and then again the upward pull of the belt, together with the lifting tendency of the tool, usually cause about as much wear in the top of the bearing as on the bottom.

LATHE HAND,

Baton Rouge, La.

* * *

COURTEOUS RULES.

Editor MACHINERY:

Dr. Thurston's rules for government of the students in Sibley College seem to me the best that I have ever seen.

The next best thing of the sort I have seen is the following, which is posted in the office of the Weston Electrical Instrument Co., of Newark, N. J.:

NOTICE.

Mr. Weston has found it necessary, in consequence of the severe draft upon his time, to see no visitors, except by previous appointment or sending a written message explaining the nature of desired interview.

How much more courteous and business-like this notice is than some which we see in other places.

W. L. C.

* * *

GUARDS FOR LATHE BACK-GEARS, ETC.

Editor MACHINERY:

I quite agree with T. B. C. in his letter in the July issue of MACHINERY, relating to the repairing of broken gears. I have repaired gears in both ways and can always get a better job by doing it in the way he describes. I also agree with him that the cross-feed screw of the lathe is not usually properly protected, but what about the back-gears? Why do not the manufacturers provide guards for these gears the same as is done on the milling machine as chips fly into them and the dust of the shop settles on them without being wiped off generally. Again, nearly every mother's son that I have ever seen working on a lathe, will put his grimy paw upon the face-gear to check the speed in stopping and in this way leave a ridge of dirt on each tooth that helps to grind them down when the back-gear is thrown in. I have, also, known cases where the workman has tried to stop the lathe quickly and has moved the shifter a little too far while his hand was on the face-gear to check its motion. The lathe has reversed its motion quickly and his fingers would be caught in the back-gears before he realized what had happened. Now a neat guard "a la miller" would prevent such accidents besides saving the gears from unnecessary wear.

I would advise F. B. C.'s friend to be not too particular about the accuracy of the divisions when making reamers, as in my experience I find it is best not to have them equal since regularly spaced reamers are likely to turn out like some old women—"chatterers."

GEO. H. NORRIS,

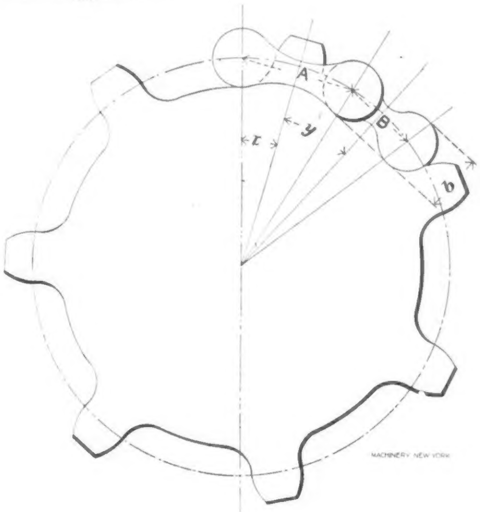
Poughkeepsie, N. Y.

* * *

TO CALCULATE THE DIAMETERS OF SPROCKET WHEELS.

Editor MACHINERY:

Perhaps some of the readers of MACHINERY have been puzzled as has the writer, by the complicated formulas for determining the pitch line of a chain sprocket wheel. The following method is the simplest that I have ever seen, and it is submitted for criticism and suggestion:



Let A = the length of the side bars and B = the length of the blocks.

The length of the side bars and blocks is usually .6″ and .4″ for the ordinary bicycle chain, so the problem then becomes one of constructing a polygon of a given number of sides and from it determining the radius of the pitch line.

S. A. C.

[Yes, but constructing the polygon from these dimensions is the rub, and is likely to prove difficult if the exact radius is required. The following formula, from Brown & Sharpe's catalogue for finding the diameter, is interesting and trustworthy:

N = No. of teeth.

b = Diameter of round part of chain block, (usually .325)

B = Center to center of holes in chain block, (usually .4)

A = Center to center of holes in side links, (usually .6)

$$y = \frac{180^\circ}{N}$$

$$\text{Tan. } x = \frac{\text{Sin. } y}{\frac{B}{A} + \text{Cos. } y}$$

$$\text{Pitch diam.} = \frac{A}{\text{Sin. } x}$$

Outside diam. = pitch diam. + b

Bottom diam. = pitch diam. − b

Suppose the pitch diameter of a nine-tooth sprocket is required, we then have

$$\text{Angle } y = \frac{180^\circ}{9} = 20^\circ$$

Since the sine of 20° is .34202 and the cosine is .93969

$$\text{Tan } x = \frac{.34202}{\frac{.4}{.6} + .9369} = \frac{.34202}{1.60635} = .21292$$

Referring to a table of sines and tangents we find that the angle for tangent .212892 is 12° 1′ 12″ and the sine of this angle is .20825. Therefore the pitch diameter $= \frac{.6}{\text{sin. } x}$ or $\frac{.6}{.20825} = 2.881$ inches. 2.881″ + .325″ = 3.206″ the outside diameter and 2.881″ − .325 = 2.556 the inside diameters.—EDITOR.]

PUSHING WORK.

Editor Machinery:

In all general machine shops where many workmen are employed it is necessary to have a systematic means for ordering work done in the shop so that the requirements of the business may be met in a general way and each department kept supplied with work that is most wanted.

A systematic means in this case necessarily implies that written instruction shall at all times be given since verbal instruction cannot be properly transmitted throughout the entire works of a large establishment. In a shop of any size, where a regular line of manufacture is carried on, it is easy to provide for a system that will insure the performance of the work first desired, but where miscellaneous work is taken in to be carried along with new work the conditions are more difficult for "pushing work." The principles involved in either case are, however, the same, and may be formulated into the same general rule.

The officers and heads of the drafting department are to make the business arrangements, such as negotiating sales and purchasing materials; also to do the planning of details and the supplying of details to the shop. Therefore, the date given a customer for the delivery of an order must be official and should be incorporated in the shop order. This principle should be carried out on work wanted at a certain hour of the day, and it supplies all that is required to accomplish the desired end.

Much might be said as to the manner in which this is to be carried into effect. Most large modern shops, however, have systems of work cards for taking work through the various departments, and all that will be required in such cases is to incorporate the time with respect to the date when it is to be delivered. Some shops have used various stamped special instructions in bold type on the work cards for the purpose of attracting the attention of the employees to the work cards that require special attention. A better plan is to use cards having a distinctive and striking color for special work and plain ones for the ordinary work. The significance of the color can be established so that it will carry "right of way," while the exact requirements can be written on the card, the color only to attract and impress the need of special attention.

When giving the date on a card for the delivery of work it is best to state the time at which the work is to be started, which necessitates the careful examination of the drawings by the foreman and the estimation of the time required for the various operations before the work is started. It will be seen that in making the estimate for the time of starting the work, it is necessary for those making the estimate to know that it can be done. Time is thus taken by the forelock, and the shop and work managed instead of having the work in the shop manage the business. The uninitiated will probably see mountains in the way, but they will all disappear or become molehills when the system is put into operation.

In connection with modern shops a "Bill of Material" is also indispensable. For each order of work, no matter how small, a bill for the material should be issued which should specify all the articles that will be required on the job. The form of the bill should be ruled for the items of the bill; also for columns provided with printed heads indicating the use of the column. Columns should be provided for Check Mark, Item Number, Detail Number, Number of Pieces, Kind of Material, Dimensions, Pattern Number, Drawing Number, Finished Weight, Rough Weight and Inspector's Check, and destination within the shop with respect to the various departments; also a space for general description of the details and materials entering into the construction. The bill should have spaces for recording the receipt of materials called for, so that the number of pieces delivered, date and the delivery card number can be entered. Sufficient spaces should be provided so that if 100 pieces are called for of a given pattern number, and if they be delivered at different times, the receipt of each lot can be recorded. The bill should be arranged so that it becomes a record of what has been done on the order and saves "chasing around the shop for information."

The bill of material should give the order number and should also have space for the title in which is written who the work is for, description, also spaces for the page number and for designating the final page, so that those concerned can tell when the bill is complete, as it is often very desirable to start work in parts before the entire bill can be written out completely, and before the drawings are detailed. If material is supplied by a customer the the bill gives him credit, or if in part only, the items are specified with "No Charge" marked following them.

It may appear to be the thing to see a foreman "tearing around the shop and chasing up work," but it is a mistaken idea. While the foreman is following up something "urgent" other work may be waiting that is equally important.

It should be borne in mind that the stock department is, by the method described, kept thoroughly in touch with the wants of each case, being informed when to deliver material and such a bill properly kept furnishes the widest possible range of information as a requisition, and also saves cost in the repetition of writing, likewise serves all purposes for the shipping department.

AN OLD FOREMAN.

BILL OF MATERIAL.

Serial Page. (Name of Firm.) Final Page.

Shop Order No.................... BILL OF MATERIAL FOR.. Complete Order............By....................

Charge to S. O. No.................. .... Ship General Order........By........ ....

General Order No.................. ....

Item No.	Check Mark.	No. Pcs.	General Description.	Detailed Description.								Date For Delivery to Successive Depart'ts.	Material Delivered.				Inspectors Finished Weight and Remarks.
				Deliver to Depart't.	No. Pcs.	Size.	Kind of Material.	Length. Ft.	Length. In.	Pattern No.	Drawing No.		No. Pcs.	Card No. / Date.	No. Pcs.	Card No. / Date.	
1																	
2																	
3																	
4																	
5																	

Lines and columns should be ruled in colors.

* * *

THE MULTIPLE POWER SCHEME.

Editor MACHINERY:

I've been kinder busy lately and the good times in the machine business have kept us humping here in Notown as elsewhere. Several new concerns have sprung up and old ones branched out till I feel sure there'll be more news for you a little later. after the boom slacks off a litt'e. But that's another story as Kip says.

I had to go to Philadelphia a few weeks ago, and after my job was finished, I met an old chum of mine who took me in tow till train time. He was deep in the mysteries of a new power-saving device and wanted me to go along to the river, so I went. Way up, pretty near Cramp's, we found a little steam launch called "The Multiple," with a steeple compound engine in her, cylinders about 3 and 6 by 6-inch stroke, but the engineer allowed that the low pressure didn't do any good because it wasn't a condensing engine. Too bad our railroad friends don't know this before they put money in compound locomotives that are not condensing. Perhaps they'll give you fifty cents to show 'em their folly—perhaps they won't.

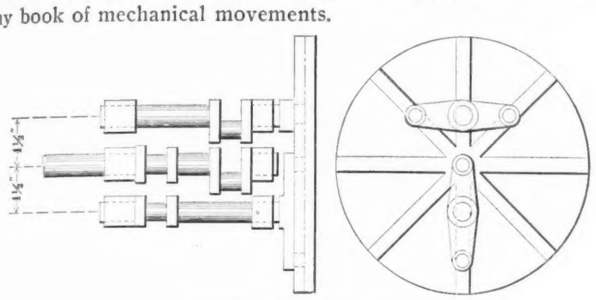
Well, we looked the thing over and found the power-saving device a rather neat affair for gearing up the propeller to turn twice to the engine's once. Kind of a Holman engine affair where you fool the engine into running the boat twice as fast as it thinks its doing. Mean trick I call it, too.

There is the disk or face-plate with eight radial slots in it.

This is driven by the engine shaft. Located each side of the main propeller shaft are two supplementary shafts with arms on the end carrying rollers which play in these slots. These arms are at right angles so as to pass each other and to avoid a dead center here.

If you'll follow the sketch carefully you'll see how it works and how each turn of the disk turns the auxiliary shaft (and of course the main shaft also) twice. But, there are some points you don't see until you're told. You might imagine as I did, that it was simply an ingenious gearing up device to accomplish the work of spur gears. That's what I thought, and displayed my ignorance so far as to ask why they didn't use spur gears, as being cheaper, simpler, and which would run with less friction.

I thought I knew a little about gears, but I don't. Gears wouldn't do at all because they have a constant pitch line, and require a constant force to keep them moving. Here its different. The pitch line is different. It moves from the center out and consequently the leverage varies and gives you a gain in power. Perhaps you don't believe it. Well, its easier to than to get any proof of it, and it ought to be plain because it saves 66 2-3 per cent. of power owing to this very variable pitch line. Its a neat device though, even if you can find practically the same in almost any book of mechanical movements.



MULTIPLE POWER DEVICE.

Well, we started on our run and it went fine, although they allowed that it took ten pounds more steam to run the boat with the "jigger" in than out, and the engine didn't hook her up but let her run full stroke—wasn't any too much power there I guess. The low pressure cylinder was choked as you could tell by the exhaust. It wasn't free enough to clear itself even at 150 turns, and probably, wasn't helping as much as it ought to, but it was doing more good than it did later. We ran over a measured course in a certain time and burned only a very little coal. Then we changed to ordinary engineering and coupled the engine on direct to the screw.

Of course, to make the same speed the screw had to turn same as before, so they simply doubled the speed of the engine and how the coal flew! There was a middle aged fat man on board who seemed skeptical, and he suggested, that it wasn't a square deal for the engine; for says he: "If the engine is economical at 150 turns it isn't at 300, and by the sound of that exhaust you're just pumping steam out of the boiler and jamming it all up in those cylinders before you let go of it. Either double the pitch of your screw or put in gears if you want a fair test—this don't tell anything except that the engine don't run right at 300 turns."

Then the inventor tried to explain how the variable pitch line business was responsible for the difference and fuel, and I could see the stout individual's back hair pull. Finally, he broke out with "ef this dingus is saving all the power why in thunder don't you put on two of 'em, then you could run your screw 600, and I s'pose you wouldn't burn any coal."

But the inventor wasn't concerned—he smiled sweetly and said "you might overdo a good thing," but deep down in the region of his pocket book he felt that he wouldn't sell any stock that trip—and he didn't. The doubting Thomas got in one more shot though for, as he clambered out of the boat he said: "I see the device is frictionless, 'cause you only stopped once on a 45-minute run to oil up."

This same wonderful power saver or creator or whatever you choose to call it, is to be applied to bicycles, sewing machines, mowing machines, locomotives or anything else that revolves and of course will be a howling success.

Now Mr. Editor, I want to know what encouragement there is for a machinist like your humble servant, trying to improve the steam engine, or anything else if its all going to be knocked endwise by such startling inventions as these. And further, how long will it be before men with capital will consult a good engineer before putting their money into a scheme like this, instead of waiting till afterward, and then wanting your opinion on it. But that's different, so I'll quit for this time. I. PODUNK.

Notown, N. Y.

* * *

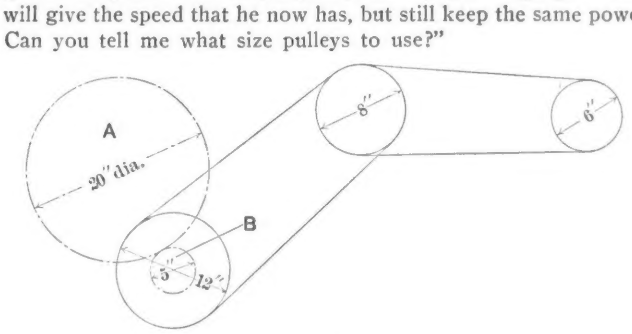
SOME EXAMPLES OF MANUAL TRAINING.

Editor MACHINERY:

There are few problems ever met with in the draughting-room of an ordinary machine shop that cannot be solved if the principles of plane and solid geometry be understood. If, in addition to the geometry, a man has mastered the essentials of trigonometry he need never fail to solve any problem that may arise in the ordinary course of machine design. Of course, some one might suggest a problem in calculating the strength of parts, or something of that nature, which he could not work immediately, but he can always find accurate tables of strength of materials from which he can make the calculation close enough for all practical purposes. There are comparatively few designers, however, who ever have occasion to calculate the strength of parts in a machine—they depend upon judgment—and my object here is to consider some of the simple problems that I have known to puzzle fellows who, to judge from their training, should have known how to solve them.

I had an apprentice working with me who was a graduate of a manual training high school, having taken a course in geometry, trigonometry, physics and mechanics, and was very highly recommended by his instructors. One day the foreman (an uneducated man, but a good workman) came into the drawing-room with a dirty sketch and gave me a problem something like the following:

I have a machine with a gear, A, 20" pitch diameter, (Fig. 1), meshing with a pinion, B, 5" pitch diameter. On the pinion shaft is a 12" pulley belted to an 8" on counter. Then an 8" pulley on counter belts to a 6" pulley on the main shaft. The foreman said "The man who owns the machine wants to discard both gears and put on shaft A, a pulley which, by changing counter, will give the speed that he now has, but still keep the same power. Can you tell me what size pulleys to use?"



A SIMPLE PROBLEM.

Now every draughtsman will immediately recognize this as an extremely simple question. We have simply to keep the ratio eight to one. Nevertheless the phrase, "but still keep the same power," suggested to me the idea of trying the apprentice with it. He sat down, and after numerous failures and guesses at the proper pulleys for the counter, succeeded in getting the required speed. Then he began all over again, and started an elaborate calculation of the movements. He had learned from physics that the movement of a body around an axis is equal to its shorter arm multiplied by the force at its extremity, but he could not satisfy himself as to what force he had acting on each pulley. After he had puzzled himself over this question for fifteen or twenty minutes, I interrupted him, and it only required a few words of explanation to show him that he had already gotten the same power when he got the same speed, for both are proportional to the diameters of the pulleys in contact.

Another problem, quite as simple as the foregoing, arose a few weeks later, and likewise proved a stumbling block to the apprentice. It was required to find the sizes of gears necessary for cutting a screw of 1 7-9 inch pitch. The apprentice examined the thread table of a lathe and found that to cut 6 threads required 48 to 48. Then he figured that to cut a thread of 1 7-9 inch pitch he must have a ratio of 10 2-3 to 1 in the gearing. A gear with 18 teeth was the smallest given on the thread table, so, in accordance with the rule he had learned in school, he multiplied 18 by 10 2-3 to find number of teeth in driver, which

gave 192. Unfortunately, however, a gear with 192 teeth was so large that it projected beyond the center line of the lead screw. The boy soon realized that he must substitute a compound, but how to find this compound was to him the puzzle.

Now, it seems to me that if I were teaching either mechanical drawing or machine shop practice in a manual training school I should feel very much mortified if any student should receive a certificate from my course (much less a favorable testimonial from me) and prove unable to solve such simple problems as the above. If a thorough training in this kind of work is impossible under the present school systems, then the systems ought to be changed, and something else sacrificed instead of the most important subject in the whole course. For if the manual training graduate cannot solve such problems with any degree of certainty, wherein is he better than the uneducated detailer who has learned to copy with accuracy and swiftness? If the boy has the principle thoroughly impressed upon him, and is required to work a large number of practical drawing-room problems, he should have no difficulty when he gets into the machine shop. I have not only noted this one apprentice, but have closely observed a number of boys from different schools and in almost every case have noticed the same defect—an inadequate training or a woeful lack of confidence. Both of these faults can be and ought to be remedied in the schools. One fellow gave me as an excuse for his unfitness, that his school, (a manual training high school) aimed to prepare the men for college. Now, if it be the province of a manual training high school to prepare for college, they certainly ought, in justice to those who cannot go to college, to give an optional course which would prepare directly for immediate practical work.

R. H. Smith.

* * *

REMARKABLE POCKETS OF SOUTHINGTON "DAGOES."

[Meriden Journal.]

Southington, Conn., June 30.—[Special.]—Carbian Caribi and Dominic Caroli were arrested this noon by Officer Cronan and Grand Juror Duncan. For some time metal has been missed by the Peck, Stow & Wilcox Company and complaint was made to the authorities.

This morning two men were detailed to watch the company's yard with the result that Caribi, an employee of the company, and his pal, Caroli, were bagged. When arrested molten brass metal was found in their pockets.

It is thought that the thieving has been going on for some time in a systematic manner. Both men were locked up to await trial this evening.

* * *

There are thousands of machinists that never read a mechanical paper simply because they are not sufficiently interested in their business to keep posted on the new devices and methods that are constantly coming into use.

* * *

MAGNETIC CHUCKS.

Among the new and improved devices for the machine shop are the magnetic chucks made by O. S. Walker & Co., Worcester, Mass. These chucks are designed to do away with bolting, strapping or otherwise fastening down work by the usual methods, which take so much of the time required to machine a piece. The chucks are for the planer, lathe or surface grinder, and their construction is extremely simple. The mechanism is simply an electro-magnet made in box form, completely enclosing an electric coil, which is not in contact with the chuck, but thoroughly insulated, so that there is no danger to the operator in handling.

A protected and guarded switch is attached to the side of the chuck and the electricity is led to the same through protected motor cord or cable.

The question of electric power, to operate the chucks, a seeming obstacle to many, is really a very simple matter. The current usually employed is from the regular 110 volt shop lighting circuit and any of the smaller chucks can be connected in place of a lamp.

The illustration, Fig. 1, is of a chuck for either planer or surface grinder and is adapted to holding a large number of small pieces at one setting. The magnetic power is diffused evenly over the face and can be increased somewhat if the pieces are blocked apart by thin strips of non-magnetic material, like wood. The

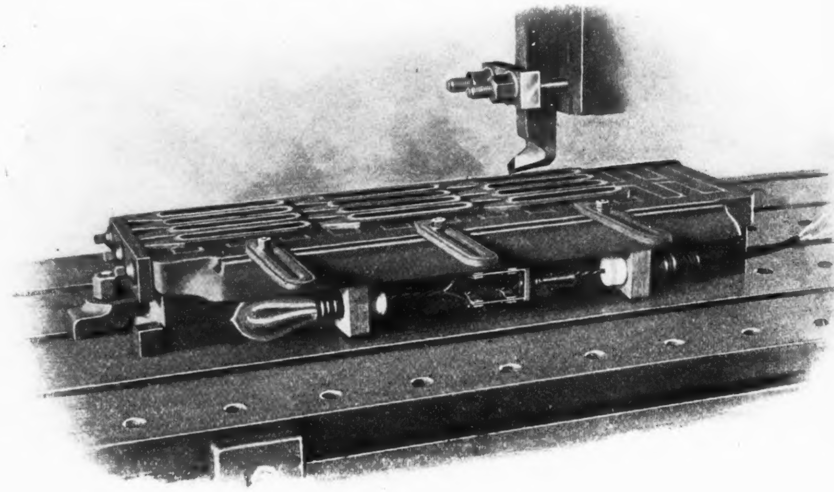


FIG. 1. CHUCK FOR PLANER.

holding power increases in proportion to the surface in contact. The larger and longer the piece, the stronger will it be held. A thin strip of steel is fastened at the back edge of the chuck, against which the work is laid. After the chuck has been covered with work, the slotted fingers shown in the foreground are laid against the outer row of pieces and act as stays. An adjustable end strip takes part of the thrust of the tool.

The object of the lamp shown in connection with the chuck is to act as an indicator, so that the workman will know that the current is on before starting his machine. An automatic switching device is also furnished, if desired, that alternately opens and closes the circuit as the platen reverses.

Another form of planer and grinder chuck is made which will hold work that is to be finished on the side as well as the top.

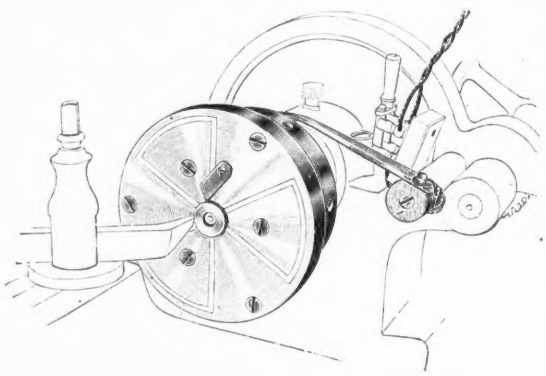


FIG. 2. CHUCK FOR LATHE OR GRINDER.

The chuck shown in Fig. 2 is adapted to grinding or turning discs or washers. In this class of chucks the magnetic gaps are radial and the piece held crosses at least six of the gaps when mounted.

The core of the chuck is bored true and then is bushed to a smaller size for the reception of longitudinally adjustable centering arbors, one of which is furnished with each chuck. The ends of these arbors may be turned to fit the hole in the work, and, where the chuck is used on a hollow spindle lathe, the work may be detached by the arbor operated by the center rod.

Fig. 2 shows the method of attaching to an engine lathe. The contact brushes (shown in shade lines), with their mountings accompany the chuck.

SHOP KINKS.

A DEPARTMENT OF PRACTICAL IDEAS FOR THE SHOP.

Contributions of kinks, devices and methods of doing work are solicited for this column. Write on one side of the paper only and send sketches when necessary.

A DEVICE FOR DISCONNECTING PISTON-RODS FROM CROSS-HEADS—TO REMOVE TIGHT KEYS FROM PULLEYS—EXTENSION FOR WRENCH HANDLE.

Mr. Wm. W. Galloway, of Buffalo, N. Y., contributes a number of good ideas to the kink department, the first being a combination of three drifts for disconnecting piston-rods from their cross-heads which every mechanic knows is often a very troublesome job. The three parts are shown in Fig. 1, which substantially shows the shape required but which may be modified to suit the proportions of the cross-head to be disconnected. The manner of using the device is clearly shown by the sectional cut in Fig. 2. A sharp blow or two on the wedge B will usually suffice to break the most obstinate fit without marring or in any way injuring the parts. By reversing the device in the keyway it can be used to draw the piston into the cross-head when connecting the two together. When the cross-head key is of very slim taper it is sometimes difficult to get the piston into the taper far enough to enter the key into the keyway but with a proper adjustment of the drifts, the piston can be readily brought to its proper position so that the key can be entered.

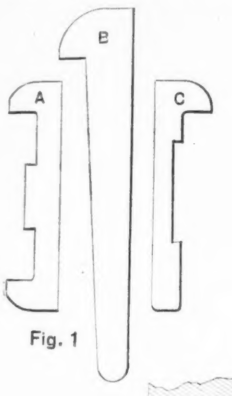


Fig. 1

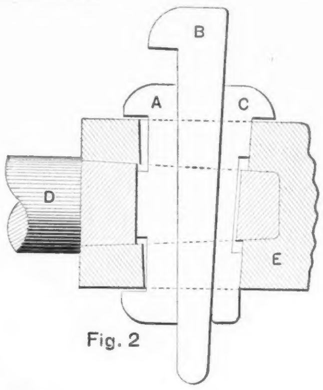


Fig. 2

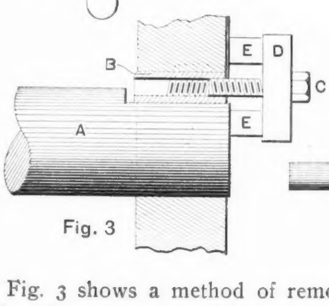


Fig. 3

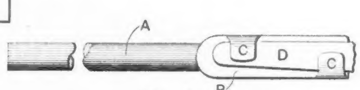


Fig. 4

Fig. 3 shows a method of removing tight keys from pulleys when they cannot be driven out with a pinch-bar. A hole is drilled through the key lengthways of as large a diameter as the key will stand and then it is tapped out for a portion of the depth. The pulling rig is then applied as illustrated which scarcely needs any explanation. It consists of the threaded bolt C and the heavy iron piece D having a hole of the proper diameter drilled in the center. The blocks E, E, raise the part D so sufficient clearance is afforded to the key. If the key resists starting, a few smart raps with a hammer on each side of the keyway will generally start the key loose.

The extension wrench handle shown in Fig. 4 is a very convenient tool to have about a shop as it supplements the length of an ordinary wrench so that the leverage can be greatly increased. When made in the form shown with the handle A of a round section, a piece of gas pipe can be used and so enable the leverage to be extended indefinitely which is a feature that will be appreciated on large nuts.

The sketch shows the wrench handle D, held by the clips C, C, which are turned over in the process of forging.

[In connection with the above it might be stated that some of the locomotives on the D. L. & W. R. R. have an extra slot cut through the valve rods just back of the tapered ends of the valve-stems. That is, a supplementary slot is so located that a drift can be inserted in it and when driven down, the valve-stem will be loosened from the rod. The idea is clearly illustrated by the sectional cut Fig. 5, but as many readers will know there is no novelty in this scheme as the practice has been followed for years of drilling a hole in this position so that a round drift could be used for the same purpose. It was in consequence with considerable incredulity that the writer noticed that Pat. ——, 188--, was stamped on the valve-rod beside the extra slot, but after some inspection it was concluded that the

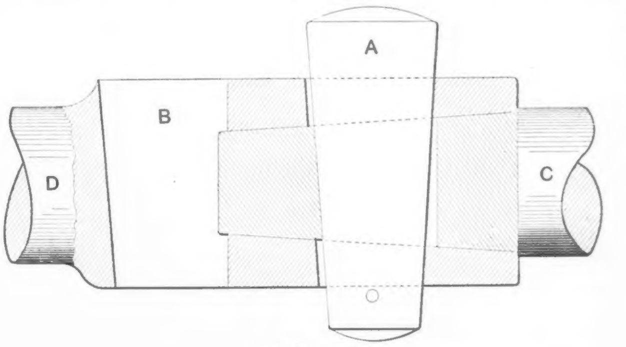


FIG. 5.

supplementary slot was so proportioned that the valve-stem key could be used for a drift in disconnecting, a feature that undoubtedly would often be of considerable value to an engineer when disconnecting on the road as his "kit" of tools usually barely comprises a hammer, chisel and battered monkey wrench. At any rate it appears that the Patent Office examiners have considered the combination of sufficient novelty to be granted protection.—Editor.]

ANOTHER WAY OF HOLDING THE DRILL ON THE CENTER.

A correspondent who signs "W. C. M." thinks that the method for holding a twist drill on the lathe center as given by Mr. Norris, in the July issue, is rather unreliable, as the belt lacing may stretch and let the drill off the center at a critical moment. He sends his method of holding the drill which simply consists of putting a lathe tool F in the tool-post D and holding back against

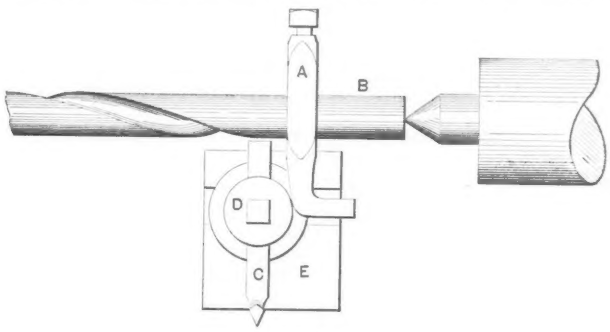


FIG. 6.

the dog A as shown in Fig. 6. The drill B is fed into the work with one hand and the carriage is allowed to move along at the same rate but with a restraining pressure on it which may be increased when the point of the drill is breaking through the work.

SOME MORE USES FOR SPLIT NUTS.

"J. E. S.," of Harrisburg, Pa., says that the scheme shown by Mr. B. F. Grout for holding studs that require threading at both ends by the use of a split nut and a lathe dog reminds him of another use that a split nut can be put to which is the holding of bolts for chamfering or pointing the ends. "Having a number of set-screws to finish that required pointing and chamfering of the heads I split a nut as shown in Mr. Grout's sketch and screwed it on to the set-screws close to the point or head as was required. The whole thing was then caught in the lathe chuck and the screw pointed or chamfered very nicely as the pressure of the chuck jaws on the split nut closed it tight enough to prevent screw from turning and still the threads were in no way injured. A split nut and a lathe dog also make an efficient means for driving or removing finished studs from work when the use of a pipe wrench for the purpose would leave unsightly scars."

* * *

The strength of a journal to resist torsion increases as the cube of the diameter so that a 4" shaft will stand nearly two and one-half times the twist that one 3" in diameter would, the conditions and material being the same.

MAKING CASTINGS ON SHIPBOARD.

"A foundry at sea had not been heard of before the cruise of the Vulcan. Whatever other kinds of naval repair work had been executed heretofore on shipboard, that of making large brass and iron castings had not been attempted. In her facilities for this new line of work, the Vulcan stands pre-eminent and alone. That the unique equipment for foundry work was successful, is more than shown by the fact that thousands of pounds of iron and brass castings were made and finished for the ships of the fleet. The brass furnaces were kept in constant service, sometimes running off two heats a day, and making it necessary to carry the work far into the night, much to the discomfort of the men, who were trying to get some sleep and rest before another day's work. In iron casting, not more than one heat was run off in a day, and that usually about 3 o'clock in the afternoon. For after filling the moulds and dropping bottom, it was practically impossible to do much more in that part of the ship until the next morning. Kipling has sung for the Scotch engineer and stoker, but there was no heaven born genius on board the Vulcan to treasure up the memories and scenes incident to dropping bottom. The usual luxuries of such work ashore were entirely missing. Like the fiery furnace of old, the heat seemed seven times more intense than it was wont to be ashore.

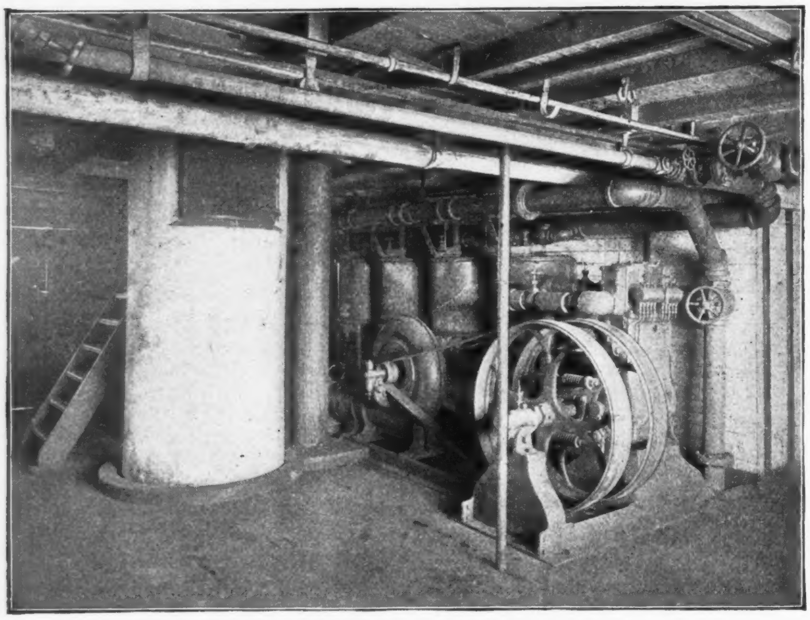


FIG. I. SHOWING CUPOLA CHARGING DOOR AND BLOWERS.

"The foundry floor was made by cutting away the three-inch wood planks of the shop deck to the steel deck plates below, laying down one-half an inch of asbestos board and then filling in to the original level of the deck with concrete, mixed in the proportion of one part of Portland cement to one and one-half of sand. Directly beneath the cupola a fire-brick floor was laid in cement on the asbestos board, and a cast-iron foot piece placed in the center to receive the bearing bar of the cupola bottom. It was rarely possible to get all of the flasks on such of the space as might be available of this 16 x 16 foundry floor. Many of the moulds had to be poured on the wood deck surrounding it, a liberal supply of water and of wet sand being kept in readiness for any emergency.

The cupola had a melting capacity of 3,000 to 4,000 pounds of iron at one heat, or a rated daily capacity of five tons, being 23 inches inside diameter. It was charged from the deck above the foundry floor, as shown in Fig. 1. In the same view will be shown the No. 5 Sturtevant cupola blower, driven by a Sturtevant double engine, supplying an air blast through 9¾ inch discharge pipe, of from 4 to 12 ounces pressure, according to circumstances. The time required to blow up for a heat was usually about forty-five minutes, from turning on the melting blast till pouring ceased. Whenever the cupola was operated, fire pumps were kept running, and men were stationed at the fire mains with hose and buckets ready for any emergency. On the spar deck and topsides bucket men were also stationed, to guard woodwork, rigging, sailcloth, etc., from the sparks of the cupola blast."—From the Engineering Magazine for June.

In addition to the foundry equipment above described, there was a forge shop, a plant with special arrangements for removing the smoke, and preventing the overheating of the space between decks. This arrangement consisted of a large steam fan and a system of exhaust piping, installed by the B. F. Sturtevant Co., whereby large volumes of air were continually exhausted through the forge hood pipes, thereby securing the double result of cooling and ventilating the space. In the matter of making this space comfortable for the workmen, it is stated that "this arrangement proved of inestimable value."

* * *

EFFICIENT BUT MISLEADING.

It doubtless has occurred to many that there was a chance to improve the efficiency of the ordinary ball bearing by providing some means for eliminating the rubbing between the adjoining balls or between the balls and the cage which carried them. A device in a New York bicycle store is used to illustrate this point. It is designed to prove the superiority of a bearing, in which the ball cage carries small rollers between each ball. These rollers do not bear upon the cones of the bearing, but simply keep the balls separated and prevent friction between them. There are two fly-wheels exactly of the same size and weight, one fitted with this bearing and one with the ordinary bearing, and it is found that the former will revolve much longer than the latter, both having been given the same impulse at the same time.

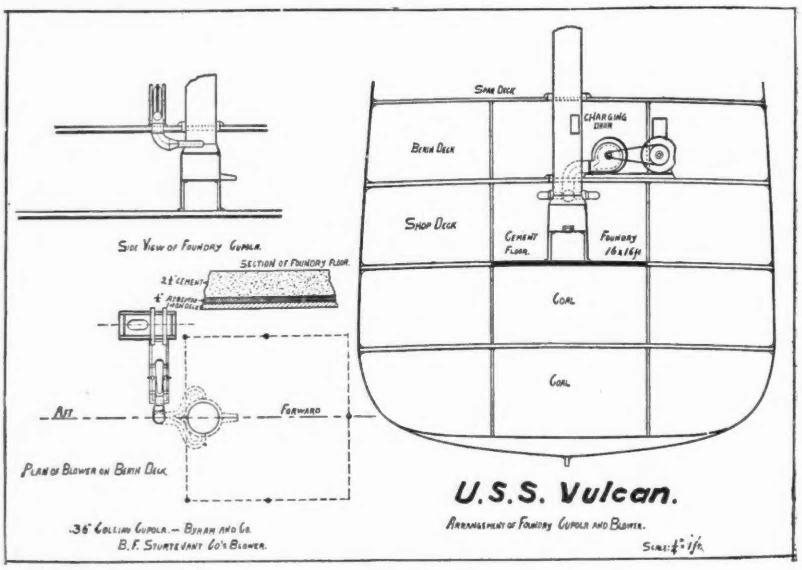


FIG. 2

This shows conclusively, that one bearing is more efficient than the other, but it is doubtful, if the efficiency under a more practical test would be much different in either case. The only correct test for such a case would be to determine the amount of power required to run the wheels with a reasonable weight upon the journals. Under such conditions, which are the conditions of practice, the power absorbed by the friction of the balls rubbing together, would be very small compared with the power absorbed by the balls rolling upon the cones. The bearing is undoubtedly to be commended, but the device used to advertise it, and which, apparently shows the efficiency to be improved 50 or 100 per cent. by its use, is misleading, and is only another illustration of the ease with which the lay mechanic may be mislead in matters mechanical. The efficiency of bicycle bearings increases with the energy expended by the rider, showing that an increase in load decreases the percentage of loss from friction.

FAMILIAR SUBJECTS IN MECHANICS.—4.

BELTING AND PULLEYS—TESTS IN ACTUAL PRACTICE.

SAMUEL WEBBER

In my last article on the subject of shafting and pulleys, I spoke of the superior hold of a belt on a wooden-faced pulley, over that on an iron one, and although this is generally known, it is often exaggerated and I, therefore, copy from my note books the results of some trials, showing the actual difference and also giving some other data, which will serve later on to illustrate some remarks on the coefficient of friction, and the actual service to be expected from belting.

The first record I copy stands as "Table 2," in my notes and I continue that heading for convenience of future reference. The belt was a heavy one, being a 5-ply cotton canvas lined with soft leather, 31 feet 2 inches long, 5 inches wide, 5-16 inch thick, weighed 19 pounds and fairly represented a double belt. It was put on to the pulleys with an initial strain of 76 lbs. per inch. The pulleys were 24 inches in diameter and 12 ft. 6 7-10 inches apart from center to center. The first trial was with iron pulleys, as follows:

Lbs. on Brake.	R. P. M.	H. P.	Per cent. Slip.	Ft. Belt per min.	Coeff. Friction.	Belt Ft. per min. per H. P. per in.	Strain per inch in lbs.
70	115.5	8.08	1.30	730	.465	466	76
80	115.5	9.20	4.	730	.541	4[illegible]2	76
90	109.	9.81	3.54	697	.613	555	76
100	98.3	9.83	0.80	684	.624	348	76

With a heavier load on the brake the belt slipped rapidly, the full coefficient of friction seeming to have been attained, and the driven pulley was taken off, a Dodge wooden pulley substituted and the tests repeated with the following results:

Lbs. on Brake.	R. P. M.	H. P.	Per cent. Slip.	Ft. Belt per min.	Coeff. Friction.	Belt. Ft. per min. per H. P. per in.	Strain per inch in lbs.
70	117.6	8.21	0	739	.483	450	76
80	117.6	9.32	0	739	.548	396	76
90	113.2	10.19	0	711	.622	348	76
109	100.	10.	13.	725	.600	362	76

These results showed but little difference in the "holding power" of the pulleys, but it was thought that the belt had probably stretched a little under the test showing 10.19 H. P. and it was taken off. The iron pulley was then replaced, the belt cut off and laced up to a strain of 117 lbs. per inch and the trials repeated as follows, as shown by my Table 3.

Lbs. on Brake.	R. P. M.	H. P.	Per cent. Slip.	Ft. Belt per min.	Coeff. Friction.	Belt Ft. per min. per H. P. per in.	Strain per inch in lbs.
70	117.6	8.23	0	739	.315	449	117
80	117.6	9.41	0	739	.350	392	117
90	114.3	10.29	0	718	.405	348	117
100	111.	11.10	1.08	704	.444	317	117
110	109.	12.	2.85	704	.480	293	117
120	105.3	12.63	5.65	698	.511	277	117
125	10[illegible].	12.[illegible]0	1[illegible].75	704	.500	280	117

I have copied this last table in full, not as bearing on the question of pulleys, but with the intention of quoting it later in reference to the coefficient of friction, which in this case was of the soft leather lining of the canvas belt on a smooth iron pulley, and also, as showing clearly how all one's tests were affected by loss of speed due to defective engine power.

I will also quote from the same table, one more test of the same belt at a higher speed, gained by changing the driving pulley from 24 inches to 46 inches with the same strain of 117 lbs. per inch.

Lbs. on Brake.	R. P. M.	H. P.	Per cent. Slip.	Ft. Belt per min.	Coeff. Friction.	Ft. per min. per H.P. inch.	Load on Belt, lbs.
70	214.3	15.	0	1343	.315	448	117
80	210.5	16.84	0	1321	.360	392	117
90	206.9	18.62	0	1301	.404	349	117
100	20[illegible].	20.	1.50	1276	.441	319	117
110	2[illegible].	22.	1.50	1276	.497	209	117
115	200.	23.	1.50	1276	.509	277	117
120	200.	24.	1.50	1276	.531	266	117
125	196.7	24.59	3.10	1276	.544	255	117
130	184.6	24.	5.50	1222	.555	254	117

This last trial exhausted the power of the engine and also seemed to show the safe practical limit of the belt, and we then took up a series of trials of wider belts, also changing pulleys occasionally to note difference in friction.

The first of this series of tests was made with a heavy single leather, "Hoyt" belt, 31 ft. long, ¼ inch thick, 12 inches wide, weighing 34¼ lbs., or a little over one pound per square foot. This belt was entirely new and was too stiff to get the best results, but the comparisons will prove interesting. It was first tested on an iron "driven" pulley, with a strain of 83 1-3 lbs. per inch, and my Table No. 5 shows as follows:

Lbs. on Brake.	R. P. M.	H. P.	Per cent. Slip.	Ft. Belt per min.	Coeff. Friction.	Ft. per H. P. per inch.	Strain on Belt, lbs.
100	109.	10.90	1.96	697	.258	768	83⅓
110	107.2	11.79	2.91	697	.280	709	83⅓
120	106.2	12.50	3.85	693	.300	665	83⅓
130	102.	13.26	5.66	679	.322	614	8[illegible]⅓
140	100.	14.	7.41	679	.340	582	83⅓
150	95.25	14.29	10.	663	.355	557	83⅓
160	92.3	14.77	13.	660	.364	538	83⅓
165	87.	14.35	17.3	717	.330	600	83⅓

The iron pulley was then changed to a wooden one, and the tests repeated, grain side to pulley, in both.

100	118.8	11.88	0	746	.263	753	83⅓
110	117.6	12.94	0	739	.289	685	83⅓
120	117.6	14.01	0	739	.313	633	83⅓
130	117.6	15.29	0	739	.341	589	83⅓
140	113.2	15.85	4.61	746	.351	565	83⅓
150	105.3	15.80	10.76	740	.353	562	83⅓
160	93.	14.88	17.33	706	.348	569	83⅓

The iron pulley was then replaced and the belt put on, flesh side to the pulley, and test repeated.

100	111.	11.11	0	697	.263	753	83⅓
110	110.	12.10	0	691	.290	685	83⅓
120	109.	13.08	0	685	.315	627	83⅓
130	107.1	13.92	0	672	.344	580	83⅓
140	106.2	14.87	0	667	.3[illegible]8	5[illegible]8	83⅓
150	106.2	15.93	0	667	.394	503	83⅓
160	105.3	16.85	0	662	.420	472	83⅓
170	Belt slipped off completely.						

The above tables will pay the young mechanic for careful study. Although, as stated, a deficiency of engine power reduced the speed in all the trials when the brake was heavily loaded, the last set was kept up to a better velocity by raising higher steam at the boilers, and there are one or two slight discrepancies in the uniform increase of friction.

Still, a comparison of the first two sets shows very fairly the difference in friction between iron and wooden pulleys, while the comparison of the second and third sets shows that the friction of the "hair side" of the belt on a wood pulley was almost identical with that of the "flesh side" on the iron one.

This, with others of the same kind, which the writer has made, entirely upset the old fallacy that more power could be obtained from a belt by using it with the "hair side" to the pulley. This is not the case, with a new belt, especially, but not true in any case.

There is another and far better reason for running a belt with the "grain side" to the pulley, and that is its increased durability. If a piece of leather belting be cut with a sharp knife and the edge where cut carefully examined with a magnifier, a very great difference will be observed in the structure of the two sides. The outer or hair side, in which the roots of the hairs are set is firm and fine grained, closely set together, while the fibres of the skin diverge from this to a much looser and more elastic structure near the flesh. The thin, outer pellicle, covering the roots of the hairs, is not very elastic and will soon crack under continued strain and flexure, while the flesh side may be doubled and bent indefinitely. It shows the wise provisions of nature in providing a firm and permanent structure for the basis of the hair which forms the outer coat of the animal, while the inner side of the skin is free to yield to the movement of the muscles to which it is lightly attached.

In passing over a pulley, the outer side of a belt is continually stretched and then relaxed again, while the inner side simply follows the curve of the pulley, although it is subject to some compression as the real center of motion is in the center of the belt, or half its thickness from the pulley. This is a matter of small moment on large pulleys, but when the diameter is small, the difference in velocity of the two sides of the belt becomes very noticeable and shows the continual change in strain to which the outer side is subjected, and which in time, will crack "the skin" on a belt if used "flesh side" to the pulley. To show that the center of motion is as stated, in the center of the belt, I will refer to some examinations and experiments made many years ago, while testing the power of cotton machinery. It was claimed that certain spinning spindles made 6,000 revolutions per minute, and the argument was, "that the

drum or cylinder, of 6 inches diameter, made 1,000 r. p. m.; therefore the spindle on which the wheel was one inch diameter must make 6,000.

Now, the number of twists put into an inch of yarn did not, by actual count, agree with this velocity, and by dropping a fine fibre of black silk into the rollers of the spinning frame and allowing it to be carried along with and twisted into the white cotton yarn, a black spiral line was formed which could be counted exactly. By fitting a rubber tube to the tip of an ordinary speed counter, and also to the top of the spindle, we were able to count the actual revolutions in that way and that count agreed with the results obtained from the count of the yarn. The two results showed that in calculating speeds, "the thickness of the belt should be added to both the driving and driven pulleys," and the diameter so obtained multiplied by the revolutions of the driver and divided by the obtained diameter of the driven to get the true speed. Now, in the case referred to, the diameter of the driving band was 1/8 inch, and adding this respectively to the 6" and 1", we get 6,125,000 divided by 1.125, which gave 5,444 revolutions instead of 6,000. This agreed with both the spindle count and the count of the twist in the yarn, or for 240 inches per minute, a twist of 22.68 times per inch instead of 25, as by the former calculation. Now this would be an exaggerated case for any ordinary belt practice, but I quote it to show the law and it applies especially to the modern systems of "rope driving."

It would seem far better, therefore, where double belts are to be used on very small pulleys, to make them in exact reverse of the usual manner and glue the grain sides together, so as to come in the center of the belt, exposing the more flexible flesh side to the strains of both extension and compression. For single belts, however, the hard grain-side stands the wear and friction of the pulley much better and soon becomes softened in use so as to cling about as closely as the flesh-side shown in the above tables.

This will be shown by the following table of tests of a so-called "Schultz Rawhide Belt," very soft and flexible, tested on the same pulleys of different kinds a few days later.

This belt had been prepared by some peculiar process, which left it so full of oil that in the final experiments the oil squeezed out and softened the varnish on the wood pulley.

It was first cut 31 feet long, was 3-16 in. thick, (12 inches wide), and weighed 29 lbs. It was first tested under a light initial strain of 45 lbs. per inch, and with a load of 9 H.P. stretched so that it had to be shortened 4¼ inches to meet at a strain of 62½ lbs. per inch. This stretched it again, with a load of 16 H.P., so that we cut out 3½ inches more, to butt it together, with the final strain of 83 1-3 lbs. per inch. The results were as follows: Grain side to pulley:

Lbs. on Brake.	R. P. M.	H. P.	Per cent. Slip.	Ft. Belt per min.	Coeff. Friction.	Ft. per H. P. per inch.	Initial Strain lbs. per inch.
100	111.	11.10	0	697	.263	753	83⅓
110	110.	12.10	0	691	.296	685	83⅓
120	109.	13.08	0	685	.315	628	83⅓
130	107.1	13.92	0	673	.341	580	83⅓
140	105.4	14.74	0	662	.367	540	83⅓
150	105.4	15.79	0	662	.394	503	83⅓
160	104.3	16.69	2.	667	.413	479	83⅓
170	103.4	17.58	2.82	667	.435	455	83⅓
180	101.7	18.31	4.42	667	.453	437	83⅓
190	100.	19.	5.66	667	.470	421	83⅓
200	90.	18.	20.	711	.417	474	83⅓
205	Belt slipped off entirely from pulley.						

It will be seen that the maximum result was reached with the load of 190 lbs., or 19 H.P. at a coefficient of friction of .470. The pulleys were then changed, and the wooden one gave as follows:

100	115.4	11.54	0	725	.262	767	83⅓
110	115.4	12.69	0	725	.288	685	83⅓
120	114.3	13.72	0	718	.315	628	83⅓
130	113.2	14.72	0	711	.341	580	83⅓
140	113.2	15.85	0	711	.368	538	83⅓
150	113.2	16.98	0	711	.394	502	83⅓
160	113.	18.08	0	710	.420	471	83⅓
170	111.	18.88	0	697	.445	443	83⅓
180	110.	19.80	0	691	.471	419	83⅓
190	111.	21.09	3	732	.485	409	83⅓
200	109.	21.80	3	718	.510	388	83⅓
210	109.	22.8[illegible]	3	705	.535	369	83⅓
220	109.	23.98	3	705	.561	352	83⅓
230	109.	25.07	3	705	.587	337	83⅓
240	109.	26.16	3	705	.612	323	83⅓
250	107.2	26.87	4.50	603	.640	300	83⅓

The last test exhausted the engine, and with the addition of ten pounds more to the load on the brake, the belt sprang off the pulleys.

At the trial with 180 lbs. on the brake, more steam was got up in the boilers, so as to keep the speed up better than with the iron pulleys.

The results again show the superior hold of the belt on the wooden pulleys, but as it did not seem to be exhausted it was cut down to 8½ inches in width and farther trials made, which will be noted in another article together with those of some other varieties of belting. I think the data I have given will repay any young mechanic for careful study and may possibly be of use to some older ones. Lord Bacon's first Aphorism was to the effect that "all science was the result of careful observation," and it is one that cannot be two deeply impressed on the mind of any young mechanic.

Some cotton spinners, 30 years ago, disputed me flatly as to the speed of their spindles, and it was not till I made them see it themselves, that they would believe that they were not making 6,000 revolutions per minute.

* * *

POSSIBILITIES OF LIQUID AIR.

The last number of *Ice and Refrigeration* contained an article upon liquid air by J. E. Siebel, who evidently does not take a rosy view of the possibilities of liquid air. We quote, from his article, but do not wish to give it either as expressing or opposing our opinions. In common with many others we are not expressing many opinions upon the subject, but are simple awaiting developments. Articles like Mr. Siebel's at least serve the purpose of preventing one from becoming too enthusiastic over new discoveries and inventions..

Much has been written about the utilization of liquid air in various ways, especially as a motive power. It is entirely superfluous here to assert the impracticability of the use of liquid air as a vehicle for motive power under ordinary circumstances. A medium in which the motive power has to be stored up at such a low temperature, entailing the loss of considerable mechanical energy, could not be considered economical for the transfer of power, for this reason alone.

As a means for the storage for power, liquid air has also been prominently mentioned by the lay press, but the very fact that it is impracticable to store or maintain it for any length of time under ordinary conditions with any degree of safety or without losing the larger portion of the liquid precludes this idea altogether. Another reason, moreover, for the unavailability of liquid air as a motive power is to be sought in the fact that not only mechanical power, but also considerable refrigerative capacity, is stored up in this medium, for which no adequate return would be obtained if it were used as a motive power for ordinary purposes.

The circumstance may not exclude the possibility of the use of liquid air for motive power in cases where expense is of little consideration, and in which certain conveniences are aimed at, as for instance for the throwing of projectiles, for the preparation of high explosives, for the propelling of torpedoes, for aerial navigation and in other cases of emergency.

With regard to the use of liquid air as a refrigerating medium, similar considerations obtain. The expense of its production is too high to render it available for ordinary refrigeration; but where very low temperature is required for specific purposes, as for the preparation and purification of certain chemicals, for medicinal uses, for physical experiments, etc., liquid air, and doubtless other liquefied gases, have certainly many advantages, and therefore, this subject cannot be ignored by the progressive engineer.

From among the specific uses of liquid air, which already have taken a more practical form, we may mention the production of liquid oxygen, for which Linde also constructed a special apparatus which is based on the observation, that when liquid air is allowed to evaporate under certain precautions, the nitrogen evaporates first, leaving a liquid containing 70 per cent. and more of oxygen. Another interesting use of liquid air is the rapid production of high vacuum. For this purpose the vessel to be exhausted is filled with a gas more easily condensable than air, say with carbonic acid gas. The vessel is provided with an extension which can be sealed off very readily. The open end of the extension is then immersed into liquid air, when the carbonic acid is withdrawn from the vessel and deposited in the extension, which is then sealed off, leaving a high vacuum in the vessel.

NEW TOOLS.

CUTTING-OFF TOOL HOLDER.

The Hill Tool Co., of Anderson, Ind., make a line of tool holders of various styles for turning, planing and boring, and have lately added another form of holder, shown in the accompanying illustration. This holder is designed for a special shape of tool which, with the holder, makes a side tool well adapted to the work. The holder is of drop forged steel, made either right or left hand, and either tool steel or self-hardening steel blades will be furnished as preferred. Those ordinarily furnished

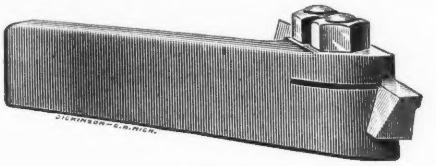


FIG. 1.

are of a special grade of self-hardening steel with a groove rolled in the cutter so as to give proper clearance. The top of the steel cutter is V-shaped and the split holder clamps down upon the V, holding it securely in place. In grinding, it is simply necessary to grind off the top, as the forward side has sufficient inclination to give the proper clearance. The bottom of the cutter is very wide, making the tool rigid and firm. This tool is said to work well in every respect and as side tools are expensive to forge and wear rapidly its use should result in considerable saving.

SURFACE GAUGE.

In Fig. 2 is an illustration of a combination surface gauge recently placed on the market by J. Wyke & Co., East Boston, Mass. The cut shows the tool so clearly that very little description is necessary. The base of the gauge is 2¾ inches long and 1⅛ inches wide. The pointer has a fine adjustment which gives

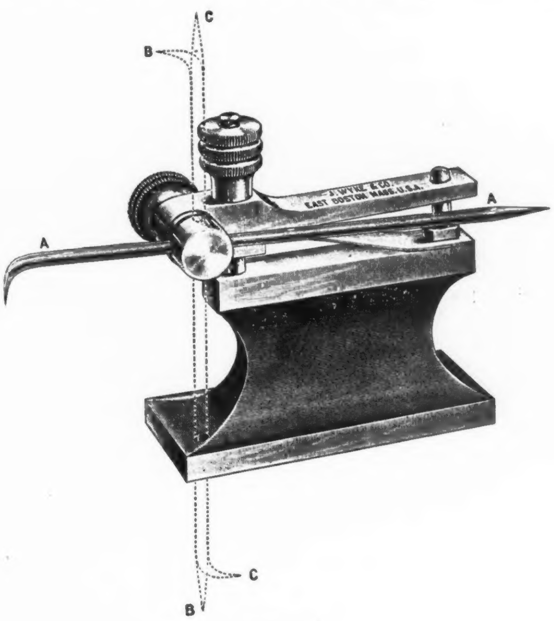


FIG. 2.

a smooth and even motion. The hole shown through the base enables the tool to be used as a depth gauge or for marking off distances on the edge of a piece of work, as indicated by the positions B. B. and C. C. of the pointer. Lost motion from wear is automatically taken up. The weight of the tool is twelve ounces.

SHOP LEVEL.

The Standard Tool Co., Athol, Mass., are introducing a new cast-iron level, which is adapted to the needs of the machine

FIG. 3.

shop and has some of the advantages of a more expensive tool. It is made like the ordinary cast-iron level except that the level glass is inserted in a cast-iron shell before being placed in the level. The shell rests on a central point, as shown in the illustration, and is adjusted by two screws which pass through the frame of the level and fit a projection at each end of the holder, securing it in place and also making the level adjustable, since a slight turn of the screws will adjust the glass, should it by any chance become out of position. In case the glass is broken, it is simply necessary to renew the glass, as it can be set in the holder and adjusted by any one. The expense of returning the level to have a new glass set is therefore avoided.

* * *

WHERE COST IS NOT THE MAIN QUESTION.

Recently discussions have taken place at the meetings of engineering societies relative to the adoption of the electric motor in place of the locomotive and in place of the horse for street vehicles. In these discussions the point mainly dwelt upon was the cost of the different means of locomotion and the one idea that seemed to be uppermost in the minds of the participants was the effect upon the coal pile and the pocket-book of the actual power taken to run the electrical system compared with the cost of coal for the locomotive or the keeping of the horse.

The "Engineering News" points out that it is not the cost of the power, simply, that tells the story, either in electric traction or even in the transmission of power in the shop. This it considers to be a minor consideration.

For example, to quote, there are hundreds of local passenger trains running in different parts of the country consisting of a locomotive, a baggage car and a passenger car, the whole run by a train crew consisting of engineer, fireman, conductor and brakeman, with occasionally a baggageman besides. Ninety-nine per cent. of the trips of these trains are made with a load no greater than an ordinary electric car would accommodate, yet such a car can be manned by two men whose pay would be not one-third as much as the pay of the crew on the steam train. What the manager wants to know is, what he must invest to make such a saving. Compared with it, the difference in cost of fuel to develop power for the two systems is a trifling matter.

Again, take the substitution of the electric motor for the horse on street railways. The gain which has been made is not measured by the difference in cost of animal traction and electric traction. The great gain is in the increased power of the electric motor, which enabled the companies to run larger cars and run them faster. These two improvements together operate to greatly increase the number of passengers which a car crew can carry in a day's work, and, at the same time, the faster and more comfortable cars have enormously increased the traffic. A third great gain is the power of operating over considerable grades with very little reduction in speeds, which has revolutionized the street transit problem in many cities.

One would sometimes think from the discussions that the loss of power in the friction of belts and shafts was the chief reason for substituting the electric distribution of power. As a matter of fact, however, this is a minor consideration. In nearly all manufacturing establishments the cost of power is a small item in the total expenditure. The advantages which make the electric motor worth its added first cost are the better control over the machinery which it makes possible, the higher speed, and increased output which it enables, the improved light which results when the forest of belts and shafting is cleared away. If in addition the drain upon the coal pile is reduced, so much the better, but this is the least important side of the story in most cases.

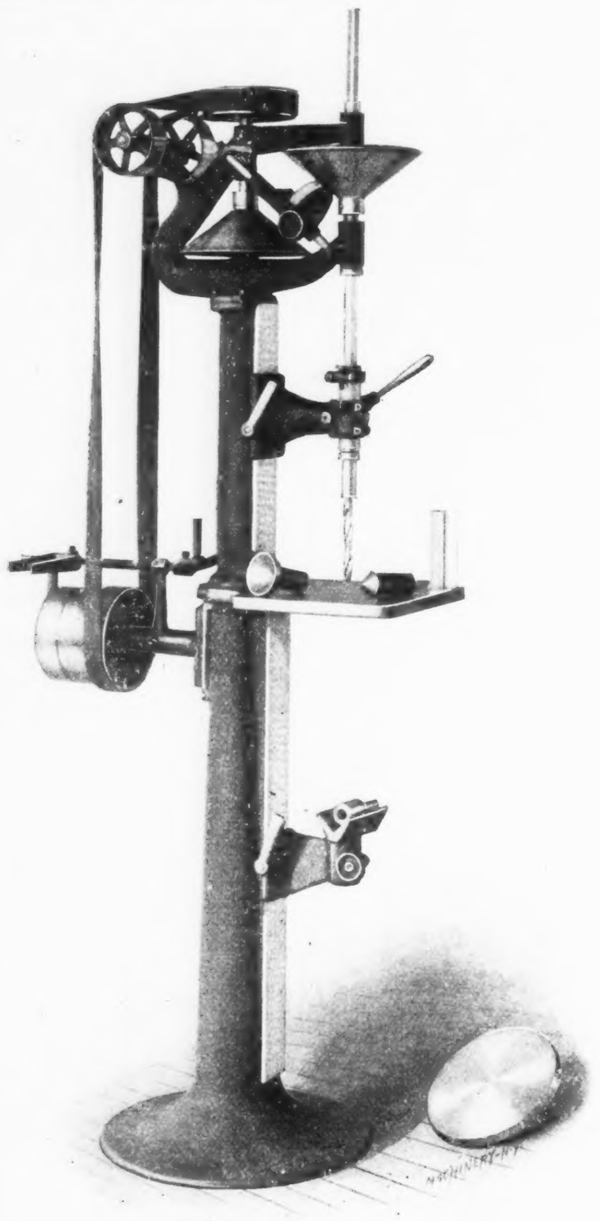
The "News" further applies the same line of argument to the motor wagon used for parcel delivery and contends that other considerations than cost are of the greatest importance. It also calls attention to the fact that the electric motor is superseding the gasoline engine for these vehicles because of its freedom from odor and noise, although at a greater cost; that it is taking the place of the cable for street railway service, where considerations of safety, freedom from breakdowns, and adaptability to the traffic are as important as the saving of power. Many other examples could be cited and the lesson from all of them is that the progress of the electric motor is due to other important factors besides the cost of the current for its operation and those contemplating its adoption should take these factors into account.

KNECHT DRILL.

The friction sensitive drill, shown herewith, has several novel as well as useful features which adapt it to a wide range of work coming within the capacity of the machine.

As clearly shown, the driving mechanism is by belt to the lower vertical cone running in bearings at the top of the column and thence through the friction wheel to the upper inverted cone which drives the drill spindle.

This peculiar form of drive permits a change in speed from the fastest to the slowest while the machine is running by moving the sliding frame carrying the friction wheel to the position that will give the desired speed, and clamping it in that position. On the shaft, which guides this frame, are graduations showing where to clamp the friction wheel to obtain the proper speed of spindle for any size drill that can be used.



DRILL WITH VARIABLE SPEED DEVICE.

The driving power of the drill spindle can be increased or diminished according to the size of the drill or nature of the work by turning a hand adjusting nut under the lower driving cone.

The sleeve on the drill spindle is graduated to indicate the depth that has been drilled and in addition there is a stop collar on the sleeve which can be adjusted and set so as to drill any number of holes to a uniform depth.

The upper cone which drives the drill spindle is supported by bearings independent of the spindle so that the latter is entirely free from lateral pressure and the spindle, when properly oiled, will run indefinitely without heating. The sleeve has ball thrust bearings.

The attachments furnished with the machine, and which are shown in the engraving, are a cup center, used in drilling holes in the ends of shafts, mandrels, etc.; a center point for supporting work when one center has been drilled; V-block with stem which fits in the lower knee and is used for supporting shafts to be drilled at right angles to their axes; and a supplementary V-block for drilling holes eccentrically or out of center in preparation for turning shafts eccentrically in the lathe. The spindle has Morse taper No. 1, and holes can be drilled up to 9-16 inches in diameter. The drill is made by the Knecht Bros. Co., Cincinnati.

* * *

SELF-CONTAINED BALL BEARINGS.

Mr. Daniel Crane, of Seneca Falls, N. Y., has invented a double acting ball bearing, with ball retaining journal consisting of but three parts—a cup a cone and a cap. In Fig. 1 is a longitudinal vertical section of one style of the journal, as applied to a shaft, in which the set of large balls carries the weight, and the set of small balls takes the lateral pressure. In Fig. 2 is another style in which the extension of the collar is cut off, the double cone

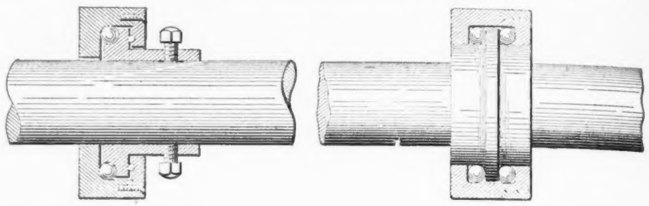


FIG. 1. FIG. 2.

being in effect a cone and a collar in combination, carrying two rows of balls, one row each side of its center. In placing the balls and cone in the cups, and fastening on the cap, it becomes one complete piece, which can be placed anywhere and detached at pleasure. These bearings are intended for use on any kind of vehicle or shafting, and it is said that the double sets of balls result in a free and easy movement.

* * *

A NEW GAS ENGINE CLUTCH.

In the installation of gas, gasoline or petroleum engines there are two important considerations which demand the use of some effective means of quickly starting and stopping the transmission of power from the engine to the driven shaft. First, in starting it is desirable and in many cases necessary to have the engine entirely free from load until the running conditions are established. Second, there is the danger involved in having machinery driven directly from a source of power, which has energy stored in a heavy fly-wheel. In case of accident shutting off the fuel supply is ineffectual because of the inertia of the heavy wheels.

These facts are generally recognized and met either by the introduction of a friction clutch pulley on the line shaft, or the old device of tight and loose pulleys. The latter is, at best, a method which is only tolerated because of cheapness of first cost, and is particularly poor in gas engine practice, on account of the necessity of a long overhang from the engine journal.

In the accompanying cuts are illustrated a new clutch designed to be placed on the engine itself, where it is within easy reach for operating, inspection and adjustment. The application of this clutch to the wheel of a gas engine requires no special departure from the ordinary fly-wheel design. The pulley carrier C, which forms the journal for the pulley and also contains all the working parts, fits over the hub of the fly-wheel and is attached by filister head screws to the bosses that are always cast on the arms for attaching a pulley.

The action of the clutching mechanism is simple and is readily understood from the sectional view. The principal is that of side gripping, which eliminates the effect of centrifugal force, and insures a positive release. In effect the faces of the pulley hub, while in clutch, are held in a circular vice. To grip the pulley it is only necessary to shove in the central spindle, S. S., by means of the hand-wheel, which is shown in section, and which freely revolves on the spindle, allowing it to be held even though this clutch be rotating. As the rollers of the central spindle travel along the faces of the fingers F. F., causing them to separate, the short arms of the levers act directly on the hardened ends of the adjusting screws, which are held securely by being threaded in the segmental faces of the pulley carrier.

Since the levers, or fingers, are pivoted on the central hub H, or the gripping plate, the resulting reaction draws the plate into contact against the face of the pulley hub. In this position the rollers press against parallel sections of the fingers, which prevents the spindle from working out after once being shoved into place.

The release is accomplished by seizing the hand-wheel and pulling the central spindle out until checked by contact of the

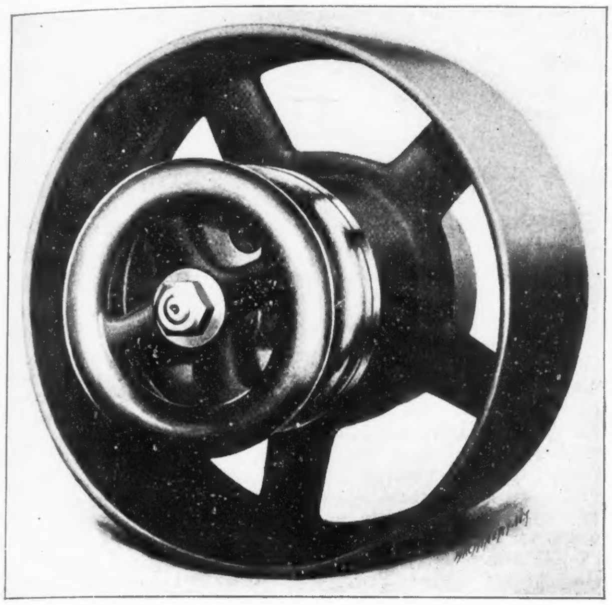


FIG. 1.

leather washers against the gripping plate. The motion of this plate is about 1-32", while the motion of the spindle is about 2". This gives an enormous leverage. It will be noticed that the shape of the fingers is such that the leverage is an increasing one, reaching a maximum just before the spindle is home.

Such wear as occurs on the gripping surfaces is taken up by a simple screwdriver adjustment of the adjusting screws and their lock nuts, the lock nuts acting at the same time as drivers for the gripping plate.

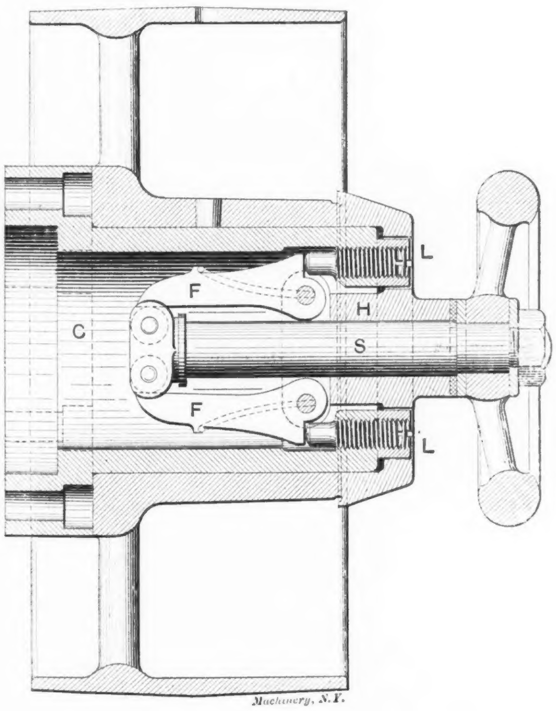


FIG. 2.

The outer surface of the clutch is entirely free from any projections, and could be safely-handled while running, the mechanism being all enclosed in a practically dust-proof case.

Although especially designed to meet the requirements of gas engine service, the clutch is evidently available for other purposes where the conditions are similar. It has been tried under severe working conditions and is said to fulfill all requirements. This clutch is the design of Ball & Corbett, of 39 Cortlandt street, New York.

* * *

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

105.—C. B. R. says that the pedals of a bicycle are usually screwed into the cranks, one having a right-hand thread and the other a left-hand thread. Why are they so made and on which side should the pedal having the right-hand thread go? A. The friction of the pedal on its pin tends to turn the pin backward as can be readily understood by a little thought, so it is good practice to thread the pedals so that the frictional action will always tend to tighten them in the cranks. The right-hand pedal should therefore have a left-hand thread.

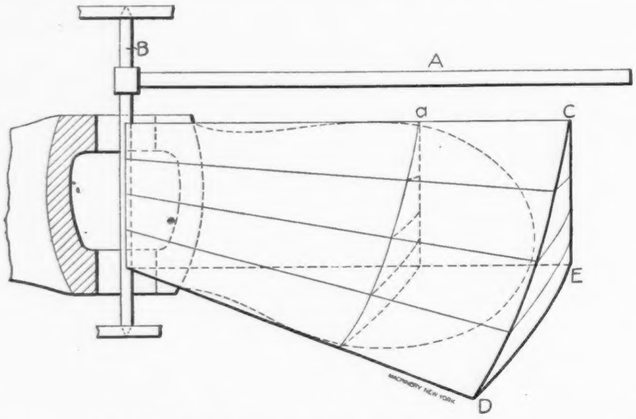
106.—J. D. says that some crank pins were recently pressed into the crank discs by a screw press in which the screw is 3.5" in diameter with three threads per inch. The lever is eight feet long from the center of the screw to the end and three men were pushing with an average of fifty pounds apiece. The nut is of cast iron ten inches long and was well oiled. The pins had a diameter of 3.5" with a length of 4" and were .005" larger than the holes.

What was the force required to force them in and what was the frictional loss in the press? I have estimated that the pressure required to be about fifteen tons. A. It is necessary to find the ratio between the distance swept by the outer end of the lever and distance traversed by the screw which is then multiplied by the force exerted by the men. The diameter of the circle swept is 16', so we have $3.1416 \times 16 \times 12 \times 3 \times 50 = 90.478$ inch pounds, which is the theoretical force exterted. It is now necessary to compute the efficiency of the screw which is very likely to prove somewhat erroneous as the conditions of lubricant, bearing surface, etc., vary greatly. Since the diameter of the screw is 3.5" we will assume that its mean diameter is 3" which gives a mean circumference of 9.424" and a total length of thread practically equal to 28.25" in three turns. If the mean diameter of the thrust bearing be taken as 2 1-3", the distance traversed by the opposed bearing faces would be 21.75" in three turns. The sum of 28.25" and 21.75" is 50" and if the co-efficient of friction be taken as .08 we can calculate the frictional loss by assuming some definite load for convenience. Taking the load to be 1,000 pounds, the loss from each inch of travel would be 80 inch pounds or 4,000 inch pounds for one inch of vertical travel of the screw. The efficiency is obtained by dividing the resultant pressure by the sum of the pressure and the frictional loss, or $1.000 + 4,000 = 5,000$ pounds. From this we have $1,000 \div 5,000 = 20$ per cent. efficiency and as the theoretical pressure was 90,478 pounds, the effectual pressure would be only $90,478 \times .20 = 18,096$ pounds or 9 tons. The per centage of loss as calculated is, therefore, 80 per cent., but the actual result may vary considerably from this for the reasons given above.

107.—R. F. P. asks: 1. Suppose I have a screw-propeller lying in a horizontal position. How can I proceed to find the pitch when I have no means of measuring except with a straight-edge, square and a two-foot rule? 2. I have a vacuum gauge showing twenty pounds. How many inches of water correspond to this?

A.—1. Fig. 1 shows the method of generating a propeller blade as it is swept up in the mould. The sweep A turns with, but is free to slide upon the vertical spindle B. As the outer end of the sweep travels along the edge C D of the guide or former C D E, it will trace a spiral curve of the shape of the face of the blade. If the sweep continued on the same spiral through one complete revolution, the vertical distance measured on the spindle that it passed through would be equal to the pitch of the screw. To find the pitch of a propeller after it has been finished, set in a horizontal position so that the bore will stand exactly plumb, or in a vertical direction. Cut a strip of wood of a length equal to the bore of the propeller and drive it into the upper end of the bore until it comes flush with the top. On this strip locate the exact center of the bore. Taking this point as a center for a

pair of dividers, describe a circle on the upper end of the hub and divide the circle into twelve equal parts, making one of the points of division come in line with the upper edge of the propeller blade. Hold a straight-edge so that one of its edges will pass through this point and also the center of the bore, taking care that the straight-edge is exactly level. With a two-foot rule measure down in a vertical direction from some point on the sweep, as from point A. Now turn the straight-edge around to



the next point of division marked on the hub (that is, move it ahead one-twelfth of a turn, or 30 degrees) and measure vertically downward to the blade from the same point, A, on the sweep in its new position. The difference between these two measurements will give the pitch of the propeller in feet. The reason for this is that, since the sweep passed through one-twelfth of a turn and the measurements were taken in inches, or twelfths of a foot, the numerical reading of the rule would be the same as though the sweep had been turned twelve times as far, making one complete revolution, and the measurements had been twelve times as great, or taken in feet.

2. It is impossible to have a vacuum gauge reading twenty pounds, since the total pressure of the atmosphere is only 14.7 pounds. Your gauge probably reads in inches and what it means is that the pressure of the atmosphere is sufficient to sustain a column of mercury twenty inches high against the pressure of air remaining in the space which we call the vacuum. If the vacuum were complete, the pressure of the atmosphere (14.7 pounds) would support a column of mercury thirty inches high, one inch of mercury balancing .49 pound. To sustain a column of mercury twenty inches high, therefore, would require a pressure of $20 \times .49$ pounds $= 9.8$ pounds and the difference between this and 14.7 pounds, or 4.9 pounds, would be the actual pressure per square inch of the "vacuum." To find how many inches of water correspond to the reading of the gauge, we have that a column of water one foot high exerts a pressure of .433 pound per square inch and to exert 9.8 pounds would require a column $9.8 \div .433 = 22.6$ feet high.

The data furnished in connection with your third question are not sufficient.

108.—G. H. writes: Please let me know in your next issue how to calculate the actual horse-power of a plain slide valve engine. Cylinder diameter, 16 inches; piston travel, 400 feet per minute; steam pressure, 70 pounds. 2. Please recommend a good book on the subject.

A. The horse-power cannot be calculated very closely without first taking an indicator card, or, if the engine has not been built, by first plotting the probable card and then calculating the probable power from that. We can, however, make an approximate estimate of the power. A good engine of this type may be expected under the best conditions, when running at its rated capacity, to have a mean effective pressure of about half the boiler pressure or in this case about thirty-five pounds. The area of the piston is $16^2 \times .7854 = 201.06$ square inches.

$$\text{Then H.P. } \frac{35 \times 201 \times 400}{33{,}000} = 85$$

2.—Hemenway's Indicator Practice, and Low's Power Catechism. Both $2 00.

109.—Apprentice writes: Kindly give a little information about (1) steel casting and (2) the production of cold-rolled shafting.

A.—"Steel castings are prepared from patterns after the usual foundry practice, but instead of being moulded in the ordinary foundry sand, special moulding compositions are used and the moulds are always well dried in the stove before the steel is run into them. Various compositions are used as moulding materials. An American mixture consists of calcined quartz, ground to a fine powder and mixed with from two to three per cent. of glue, water and flour. This composition is used as the moulding material but it is faced with a mixture of fine quartz powder and a little graphite and water."—*Greenwood's Metallurgy*.

2.—We are unable to give details of cold rolling process. Information is invited from those acquainted with that line of work.

* * *

FRESH FROM THE PRESS.

THE STEAM ENGINE INDICATOR AND ITS APPLIANCES, by William Houghtaling. Published by the American Industrial Publishing Co., Bridgeport, Conn. 307 8vo pages, illustrated. Price $2.00.

This book contains thirty-three chapters, treating of the usual subjects pertaining to indicator practice and also to some extent of steam engine economy. The author states that the preparation of the book has taken most of his spare time for a number of years. Algebraic formulas have been avoided and attention is given to cards from oil and gas engines and ammonia compressors as well as from steam engines.

It must occur to the reader that there is hardly room for another book on the steam engine indicator unless that book presents new facts, is strictly up-to-date and is of superior merit throughout. None of these things seem to be entirely true of this book, as a brief reference to certain sections will show.

The chapter upon "The Economy of Expansion" is to all intents and purposes taken from Hemenway's "Indicator Practice and Steam Engine Economy" without credit, the phraseology being changed in unimportant details only. This chapter, at least, presents no new facts.

The author advocates the use of the barrel calorimeter by engineers in preference to the throttling or separating calorimeter to which he merely alludes, and incorporates the regulation amount of matter about the "true theoretical curve," methods of locating the point of cut-off and determining the amount of clearance by geometrical constructions, etc. The use of the barrel calorimeter and the importance which the author attaches to conclusions drawn from the "true theoretical" or hyperbolic curve we do not consider to be in accord with modern ideas.

Finally, as to the general excellence of the work, the chapters upon isothermal and adiabatic expansion are in error in several respects, one illustration of which will suffice. At the beginning of chapter 15 the author says: "The curve formed in accordance with the principles of the Mariotte law depends for its correctness upon the condition that the temperature of the steam in the cylinder remains the same during the entire stroke and the curve that coincides with this law is the Hyperbolic or Isothermal in which it is assumed that the steam within a cylinder is exactly the same temperature throughout the length of the diagram." In another place he states that one of the reasons why the true expansion curve does not coincide with the "true theoretical curve" is because the temperature of the steam changes during the stroke. As a matter of fact, the true isothermal curve for saturated steam is a straight, horizontal line and if the temperature of the steam in the cylinder were to remain constant, its curve of expansion would depart more widely than ever from the Hyperbola.

In spite of its defects, the book undoubtedly represents a great deal of conscienscious work and the larger part of it will prove instructive to engineers who are studying the indicator. The points that we have mentioned indicate, however, that the reader needs to be on his guard when reading its pages.

CHIMNEY DESIGN AND THEORY, by W. W. Christie, M. E. Published by D. Van Nostrand Co., New York. 164 8vo pages. Illustrated. Price, $3.00.

This work evidently fills a vacancy in engineering literature, as up to this time only one book has been published in the United States on chimneys and that only takes up the subject of chimney draft. The only English work on this subject of any pretensions is that of Bancroft's, which is said to be out of print. In view of this fact it would seem that there is a good opening for a reliable work on this somewhat neglected branch of engineering, a statement that unhappily cannot be said of many new books recently published. The author has quoted extensively, giving his authorities with scrupulous accuracy, and takes very little credit to himself for any matter that appears.

The book contains eleven chapters, which treat of the subject as follows: Introduction and history, theory of chimney draft, chimney formulae, chimney tables, foundation materials, brick chimneys, chimney performances, house chimneys, lightning protection, general information. We consider that this work will form a welcome addition to any engineer's library.

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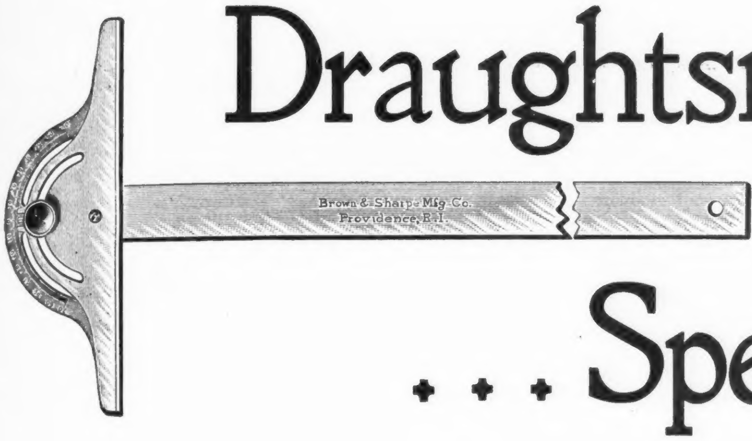

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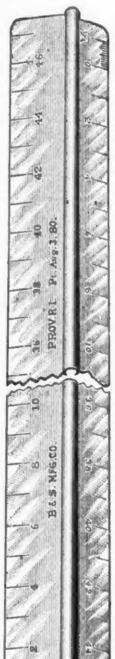

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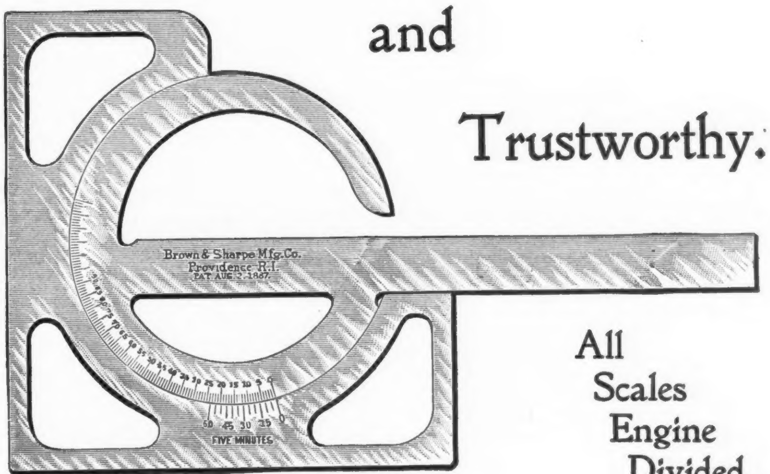

PROTRACTOR.

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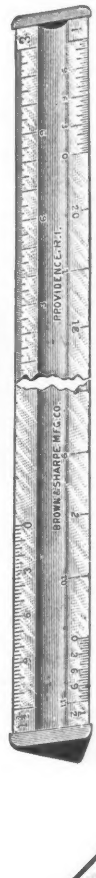

METALIC SCALE.

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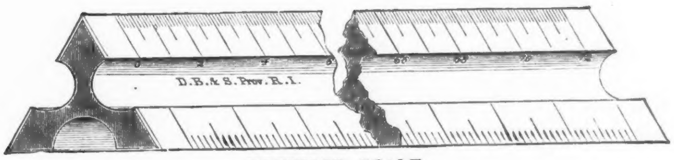

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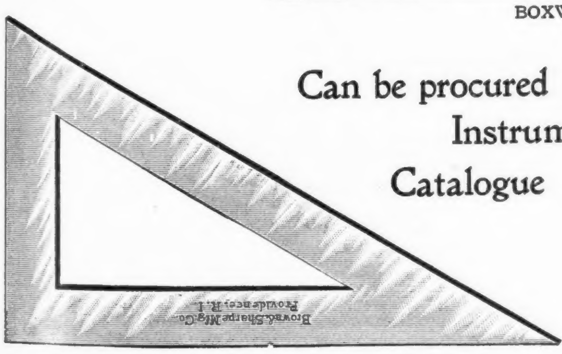

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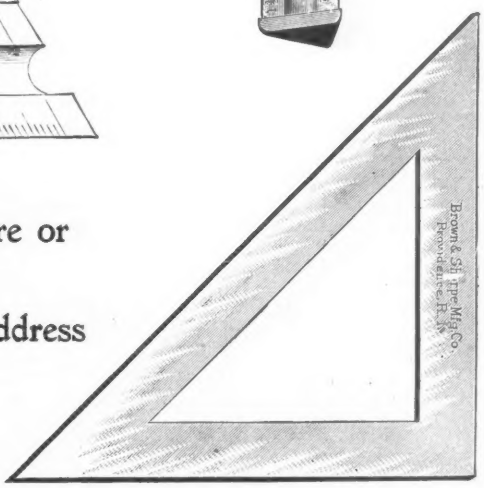


ADVERTISING LITERATURE.

The Textile World, Boston, Mass., have issued their Directory of the Mill Trade and Buyers of Textile Fabrics, for 1899. It contains 400 pages and gives full particulars regarding the mills of the country and their products. There are large lists also, of jobbers and large retailers, dealers in raw materials, clothing manufacturers, and all together it forms a complete directory of the textile industry. The price is $3.00.

The August number of the "Century" will be a mid-summer and travel number, and will contain a number of articles that will be attractive to men interested in electricity. Among these is a paper contributed by Prof. Cleveland Abbe upon "Tornadoes," and another in the same line by Prof. John Trowbridge, of Harvard, upon "Powerful Electrical Discharges." Alexander J. Wurts, of the Westinghouse Co., writes an article upon "The Protection of Electrical Apparatus Against Lightning." Three of these four articles are illustrated.

The Wilson Laundry Machine Co. have sent a catalogue showing a variety of machinery quite different from that with which most mechanics are familiar. Among the machines is an ironer of new design in which a chain drive is used. A letter sent us by the designer, Mr. E. G. Smith, says that this drive confirms the opinion recently expressed in these columns that it is an advantageous arrangement in many places.

The Millers Falls Co., Millers Falls, Mass. Catalogue No. 25, of mechanics' tools and hardware, 74 pages, 6 x 9, illustrated.

The tools made by this company include a large line of bit braces, vises, jig saws, chisels, levels and other small tools for the mechanic and amateur. The tools of the greatest interest to the machinist are the well-known Star hack-saw blades and the Star power hack saw.

The Joseph Dixon Crucible Co. have issued an illustrated pamphlet upon brazing bicycle frames by immersion. It is claimed for this process that there is no burning of the tubing, that the spelter penetrates every point, and that the work is better and neater than flame work. A careful perusal of this pamphlet will well repay any mechanic and we have no doubt it will be sent upon application.

The B. F. Sturtevant Co., Boston, Mass., have issued one of the most artistic circulars that has recently come to this office. It is entitled "2,500 Witnesses, being a list of buildings and sundry steamships wherein the Sturtevant system of apparatus has been installed for the purpose of ventilation and heating."

MANUFACTURERS' NOTES.

The American Steam Gauge Co , Boston, Mass., announce that Mr. J. L. Weeks, who has for the past twelve years been in charge of their western branch as manager and special representative, has now been elected treasurer and general manager of the company.

The Cling-Surface Manufacturing Co. report rapidly increasing sales, not only in this country but many orders are being received from Australia, Europe and South American countries with a fast growing business in Mexico, all seeming to prove the truth of the oft-repeated phrase, "The days of tight belts are over."

FOR DELIVERY SEPTEMBER FIRST, a large variety of second hand lathes, planers, drills, etc., in good order. For list and particulars address JOHN A. CROSS, P. O. Box 218, Providence, R. I.

SMALL STEAM ENGINES AND BOILERS.—Castings $2.00 up. Also castings for water motors, gas engines and locomotives. Circulars free. Grant R. Sipp, Paterson, N. J.

FOR SALE CHEAP, ONE SEVEN INCH AMERICAN STOKER, made by American Stoker Co. of New York. In good order. Apply to W. Ames & Co., Jersey City, N. J.

PATENT RIGHT FOR SALE.—The British patent right on a valuable machine tool favorably known and thoroughly introduced throughout the United States. For full particulars please address "MACHINE TOOL," care of Machinery, 9-15 Murray Street, New York.

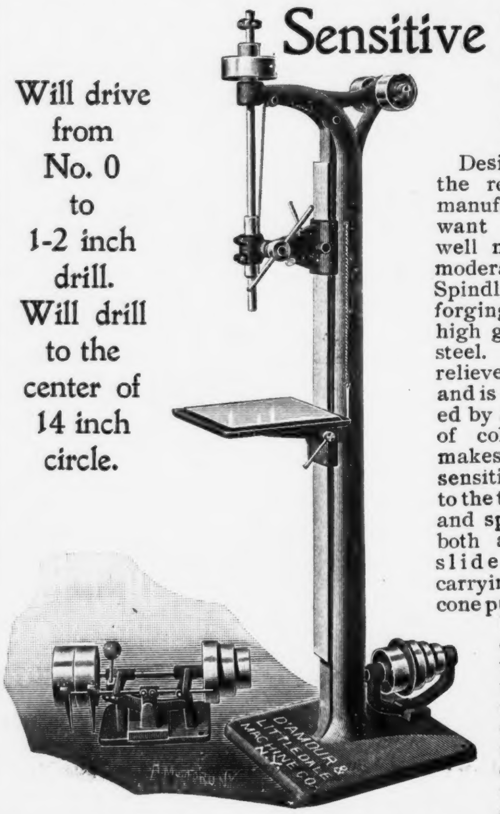
SECOND HAND TOOLS WANTED.—One 30 inch Horizontal Boring Mill; one 24 inch Shaper; one Iron Planer from 38 inch to 42 inch with bed from 8 to 12 feet. These tools must be strictly first-class and at a low price. Address "SECOND HAND," care Machinery, 9-15 Murray St., New York.

RECEIVER'S SALE.—By order of the Supreme Court I am directed to sell the property of The Mitchell Heater Co., of Poughkeepsie, N. Y. The property to be sold includes the patterns, flasks, and machinery for making high grade hot water and steam heaters, including letters patent, together with the stock of heaters on hand. Also a fully equipped machine shop and foundry for general work. For further information relating to the property, address Chas. F. Cossum, Receiver, 35 Market Street, Poughkeepsie, N. Y

CONTENTS FOR AUGUST.

14 inch Manufacturers' Sensitive Drill No. 1.

Will drive from No. 0 to 1-2 inch drill. Will drill to the center of 14 inch circle.



Designed to meet the requirements of manufacturers who want a thoroughly well made tool at a moderate price. The Spindle is a special forging made from high grade spindle steel. It is entirely relieved of belt strain and is counter-balanced by a weight inside of column which makes it extremely sensitive and uniform to the touch. The table and spindle head are both adjustable on slide. The bracket carrying the driving cone pulley is securely bolted to base of machine, thus preventing vibration of column when machine is running. A thoroughly well made and reliable overhead counter-shaft furnished with machine, and included in the price.

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MACHINERY:

VOL. 5. NO. 12.

PUBLICATION OFFICE
9-15 MURRAY STREET
NEW YORK CITY.

AUGUST, 1899.

A PRACTICAL JOURNAL FOR MACHINISTS AND ENGINEERS
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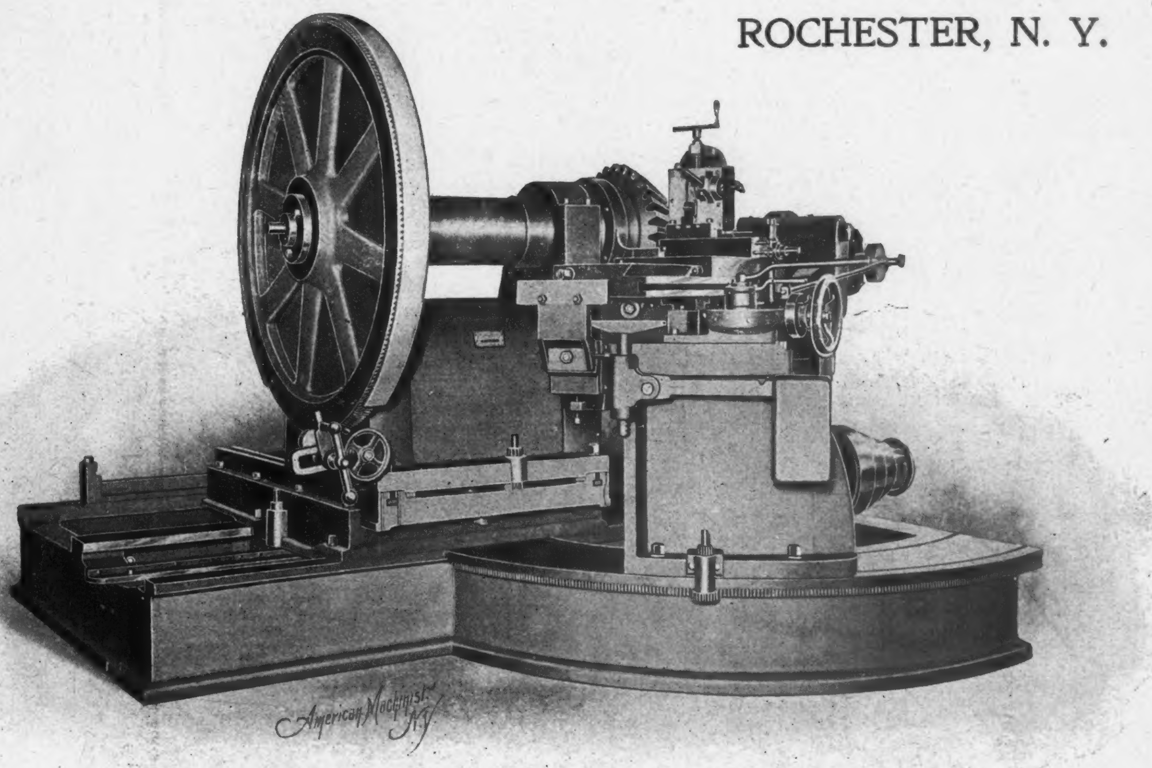

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THE only machine which cuts through the scale of cast teeth and so avoids the shrink holes common in teeth of 2½" pitch and coarser cut from the solid, saves the time of the slotting cut and the expense of the big cutter. It also gives perfect reducing cut to bevel gear teeth.

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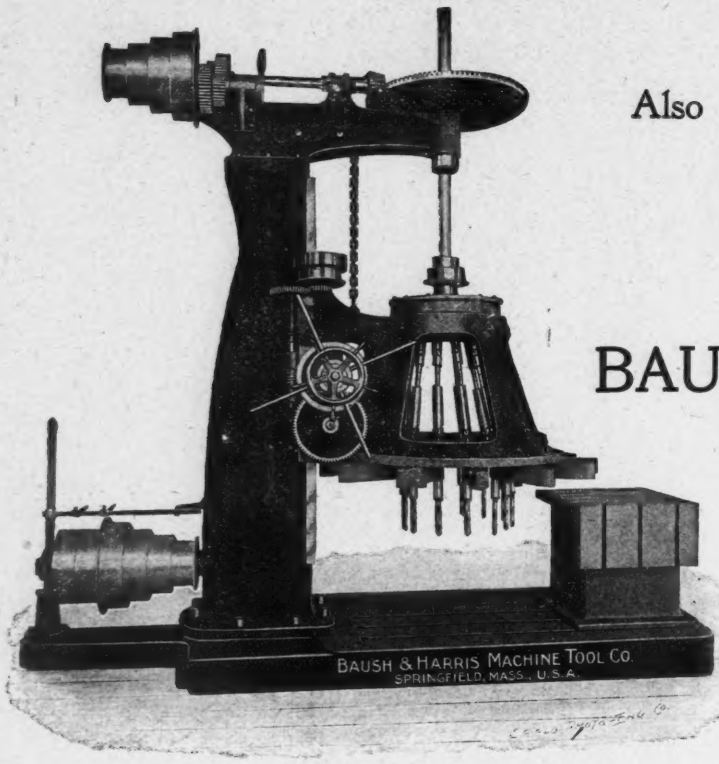

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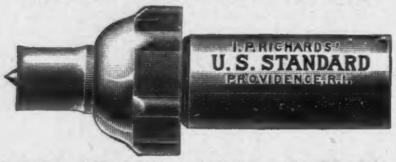

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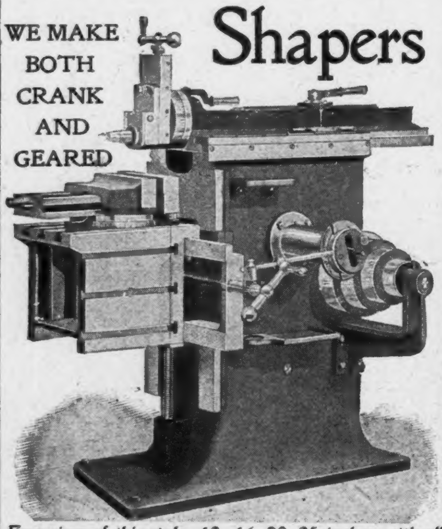

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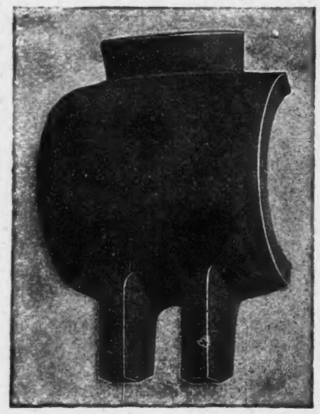

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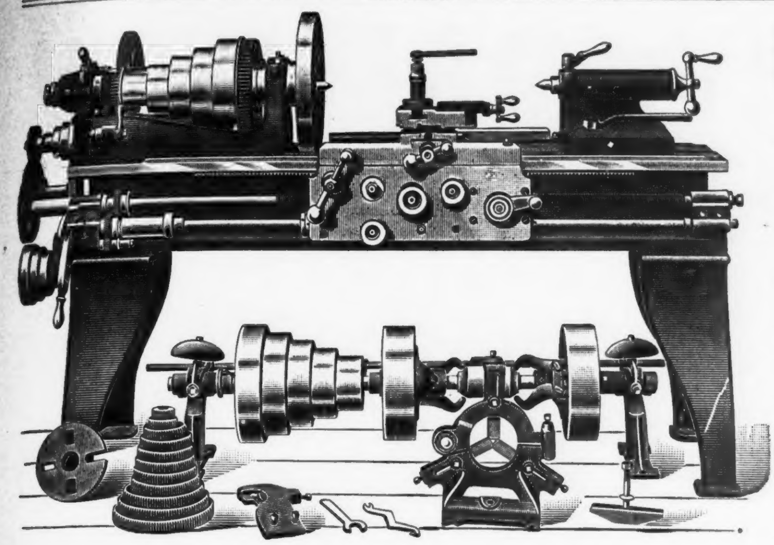

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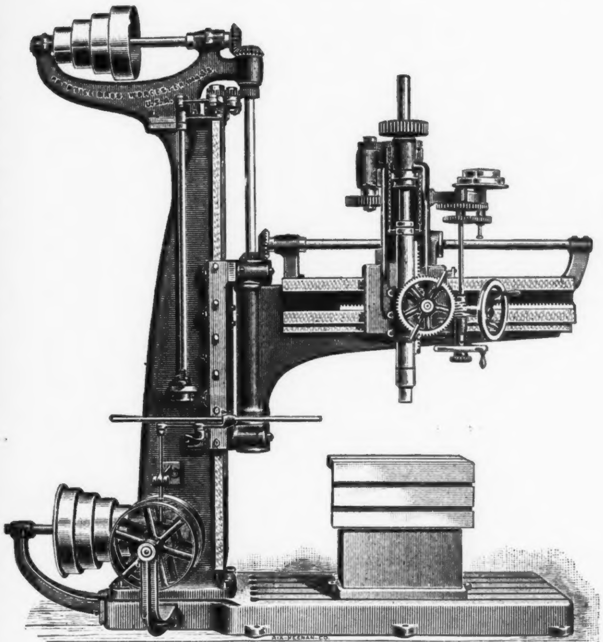

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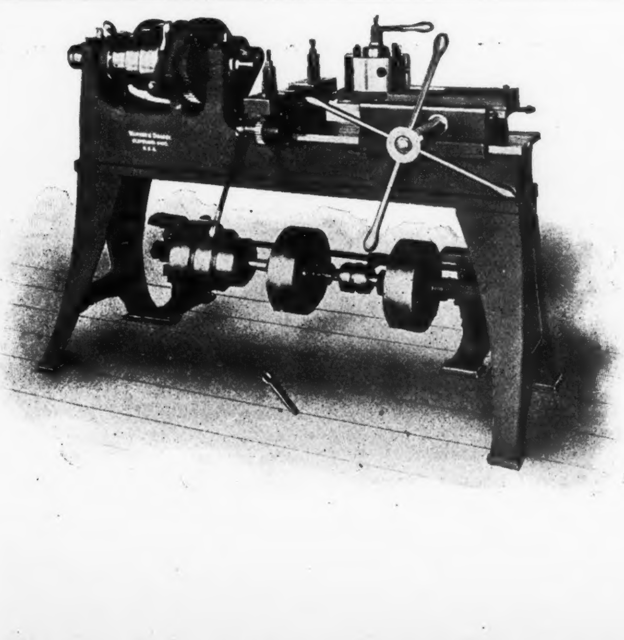

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Affords additional means of fastening and manipulating work. Prevents springing when taking heavy cuts. As the support communicates directly with the table and "Extension Base" the weight of the table falls on that projecting portion. Result: INCREASED RIGIDITY.

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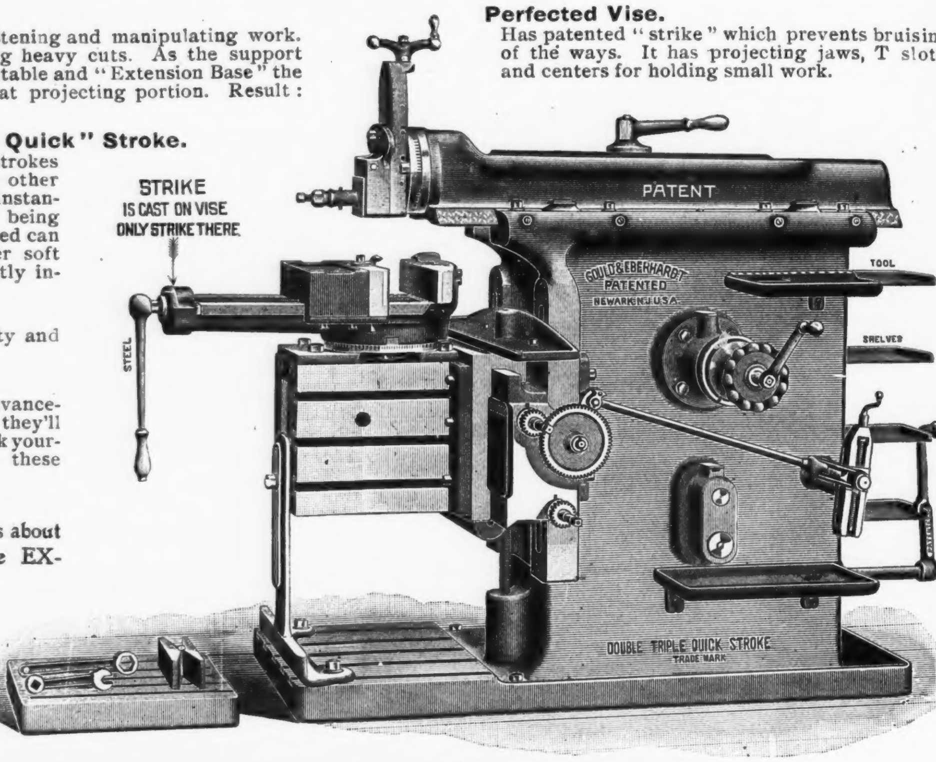

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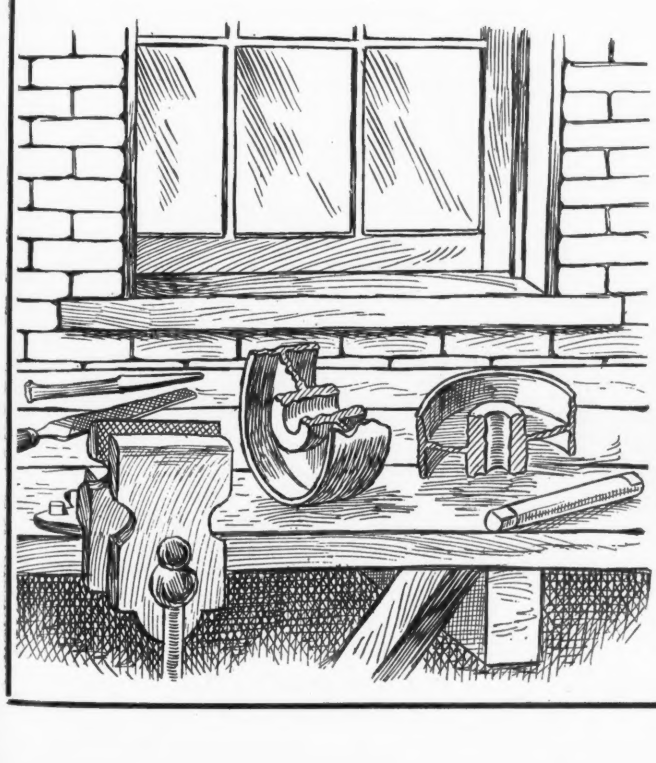

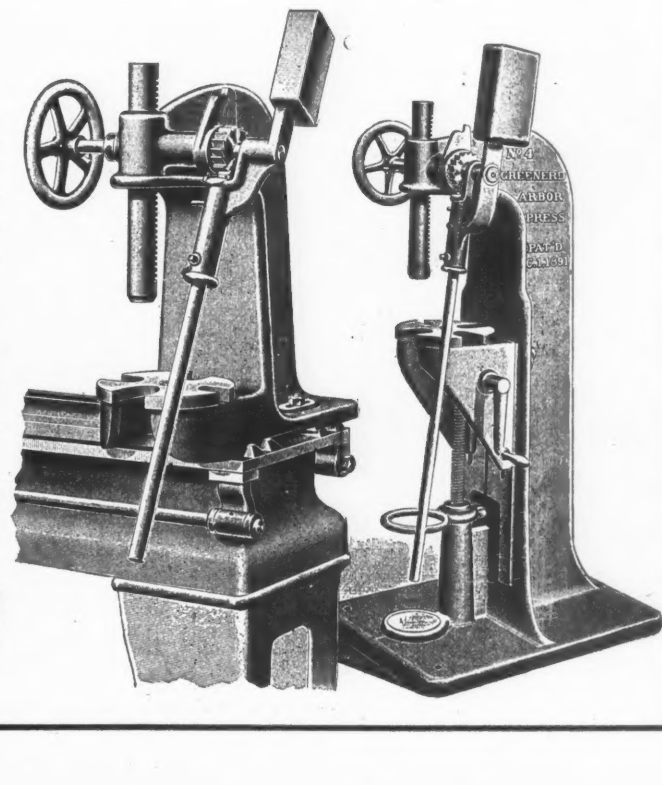

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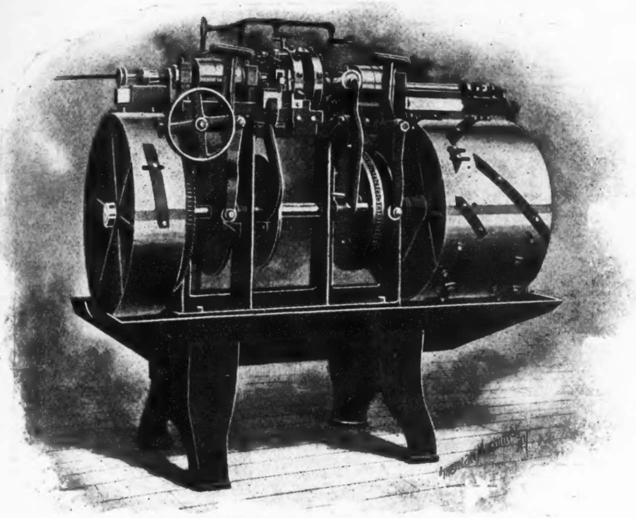

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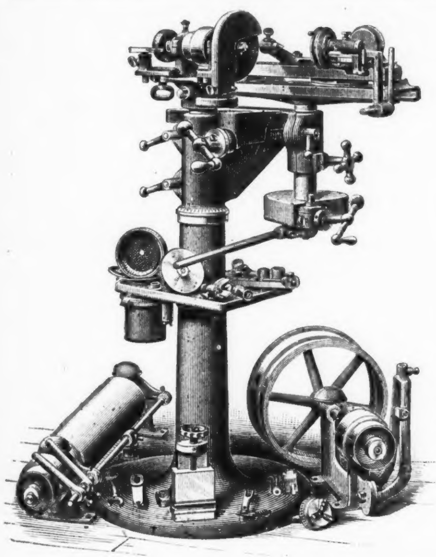

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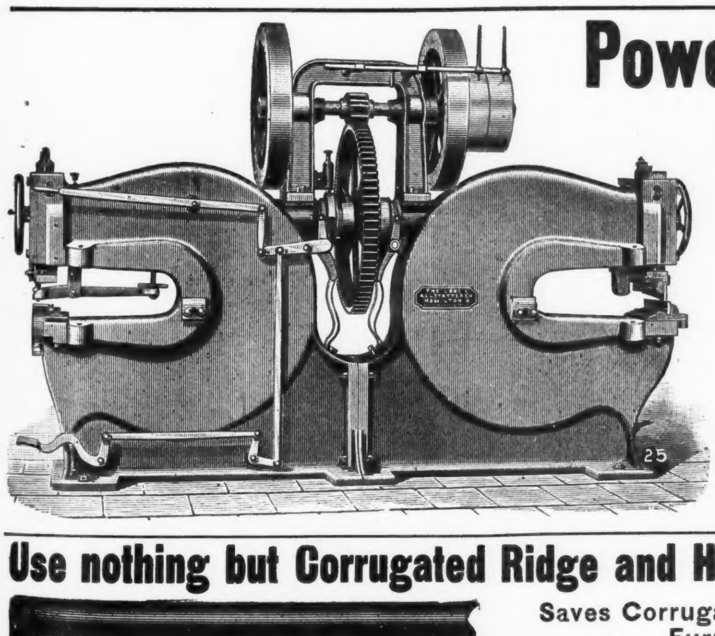

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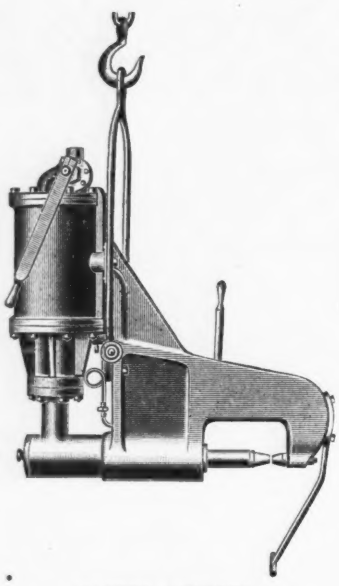

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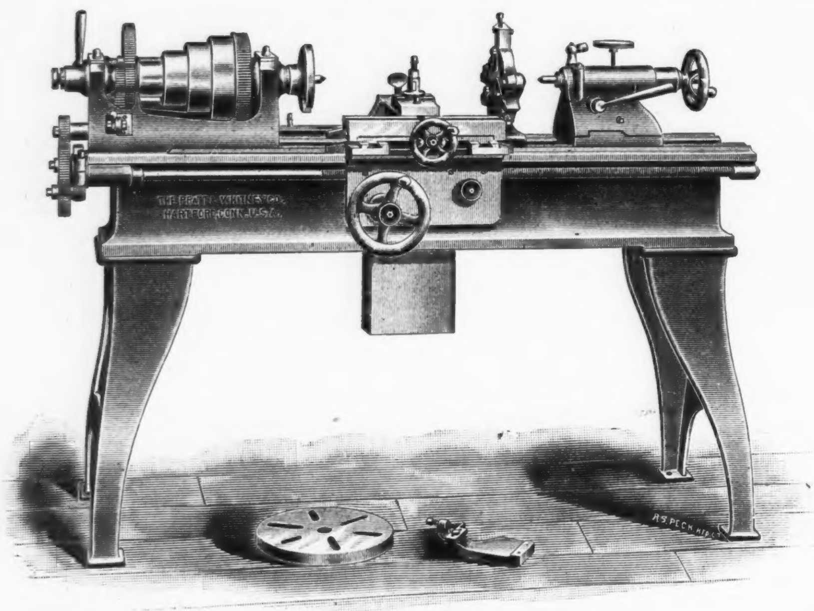

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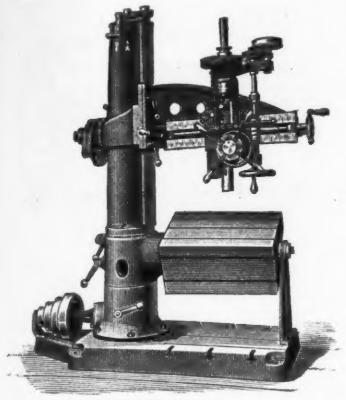

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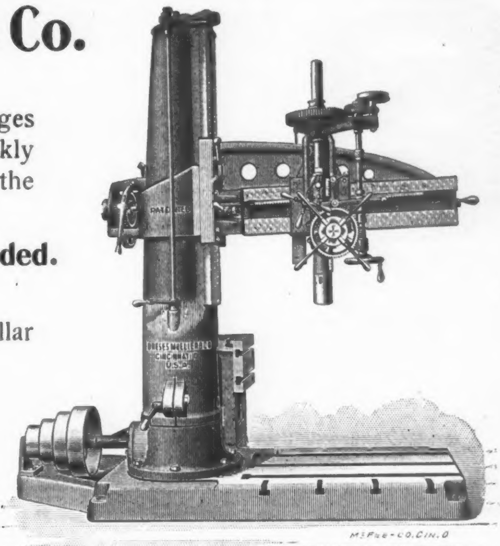
The <u>Lever</u> starts, stops, engages the back gears and reverses quickly for tapping without stopping the machine.

No special tapping device needed.

New Quick Return to spindle.
Feed variated by shifting a collar while running.



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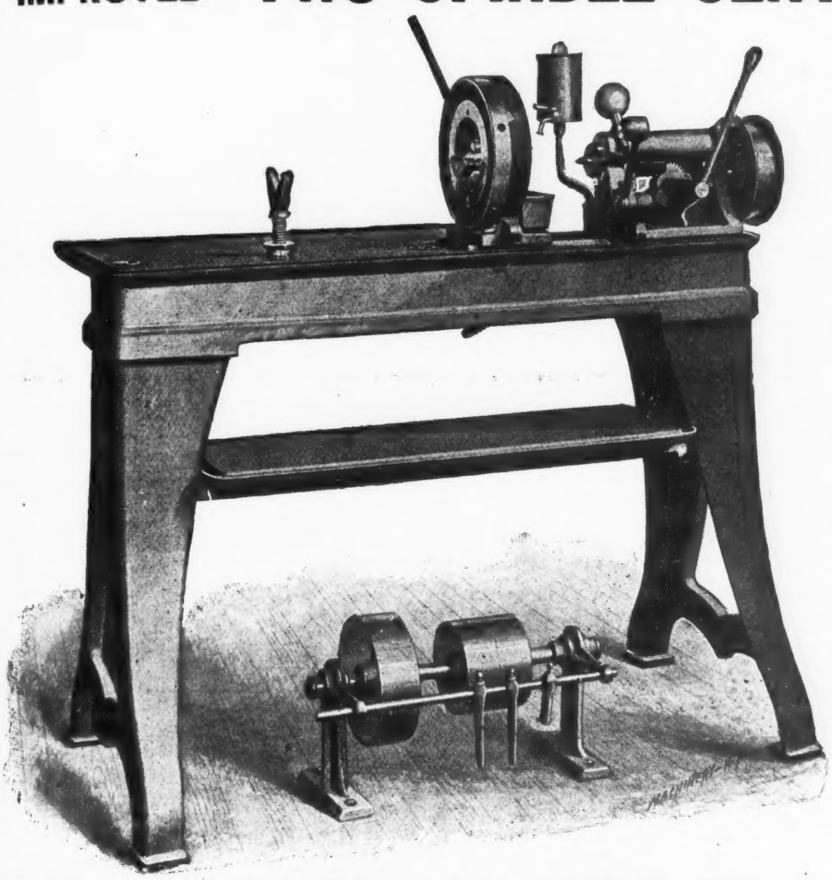

Capacity, 1-4 to 4 inches.

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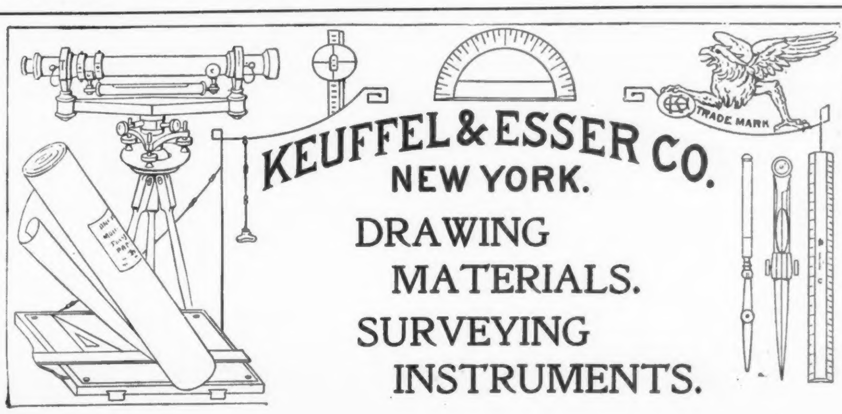

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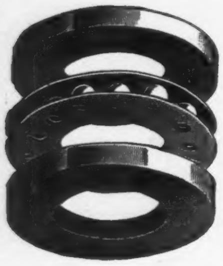

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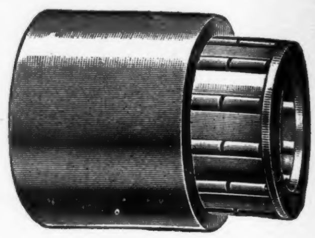
Machine Construction, Shafting and Vehicles.



Save power, increase speed, are durable and inexpensive.

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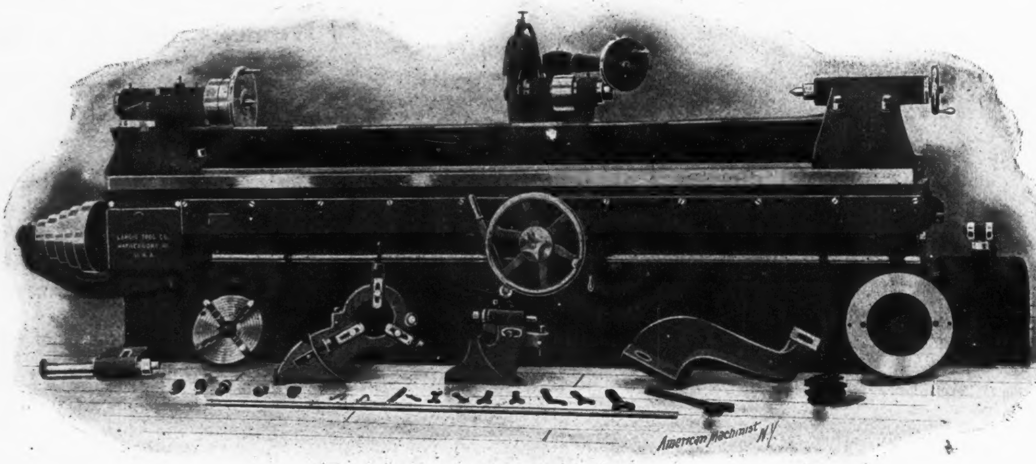
Accuracy possible on Large Work.

Instead of finishing your large work on a lathe, save time and money by using one of our No 5 Universal Grinding Machines (shown herewith) 20 in. swing, 96 in. between centers.



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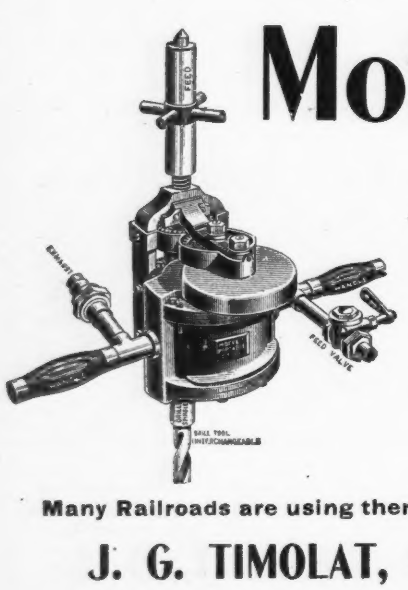
The Improved

Moffet Portable Drill



has more good points than any other drill made.

The boring spindle is attached to the side of the motor so that holes can be drilled within one inch of a straight wall. This also relieves the motor of any friction or binding of internal parts from any pressure on drill. Where the drill spindle runs through the center of motor, the friction is generally greatly increased and more power required.

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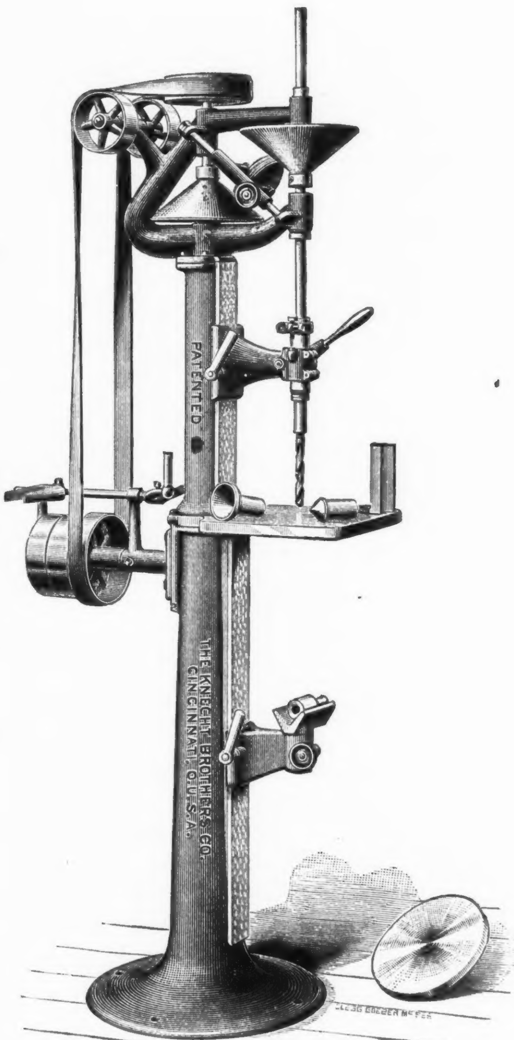

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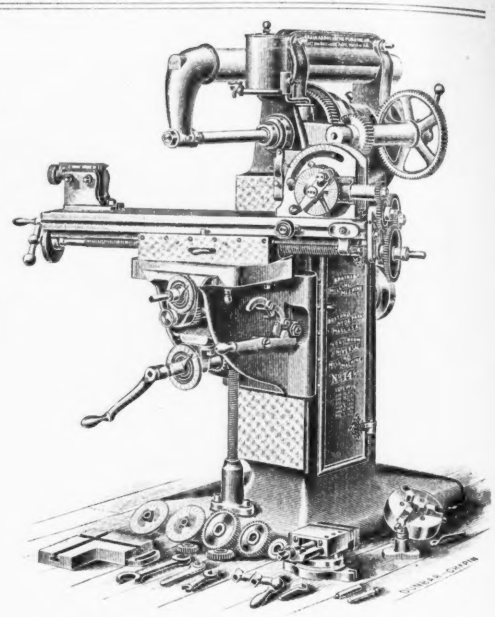

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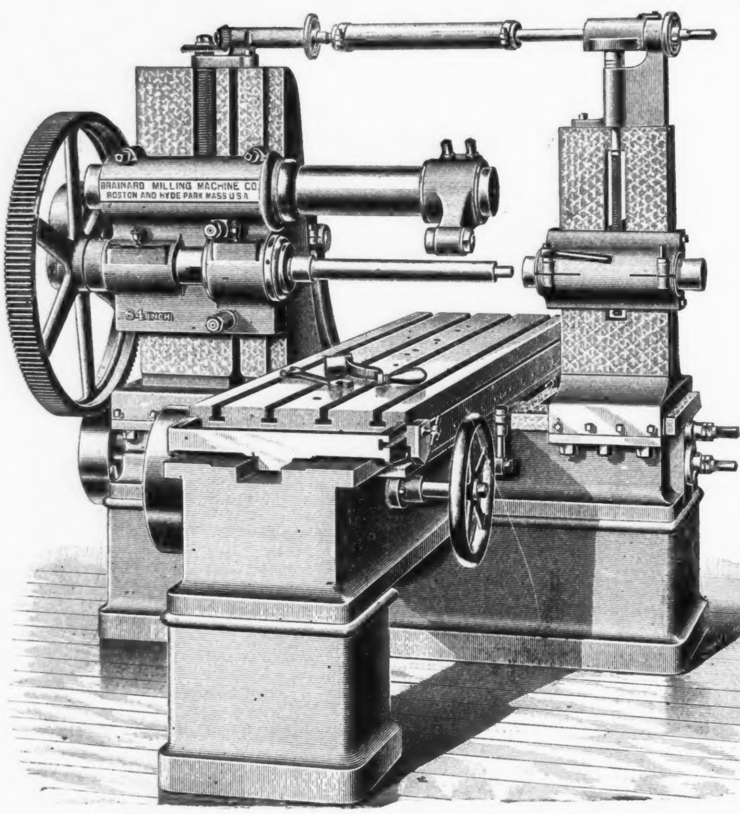

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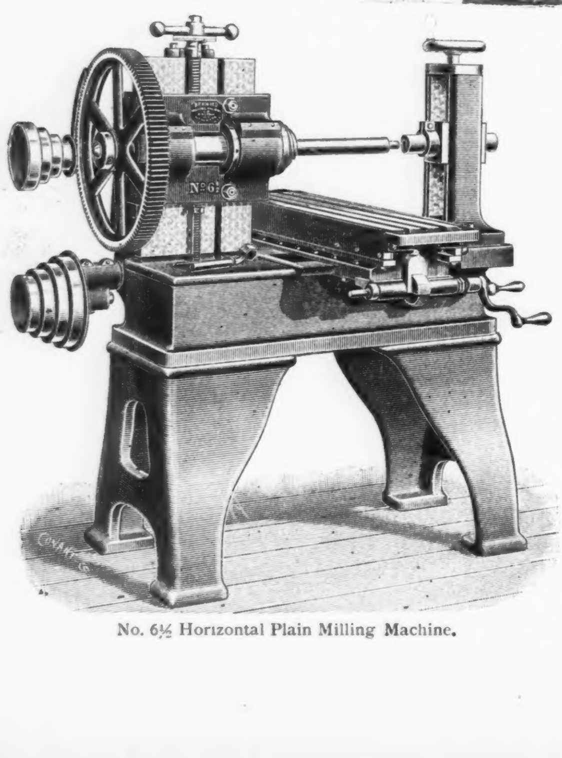

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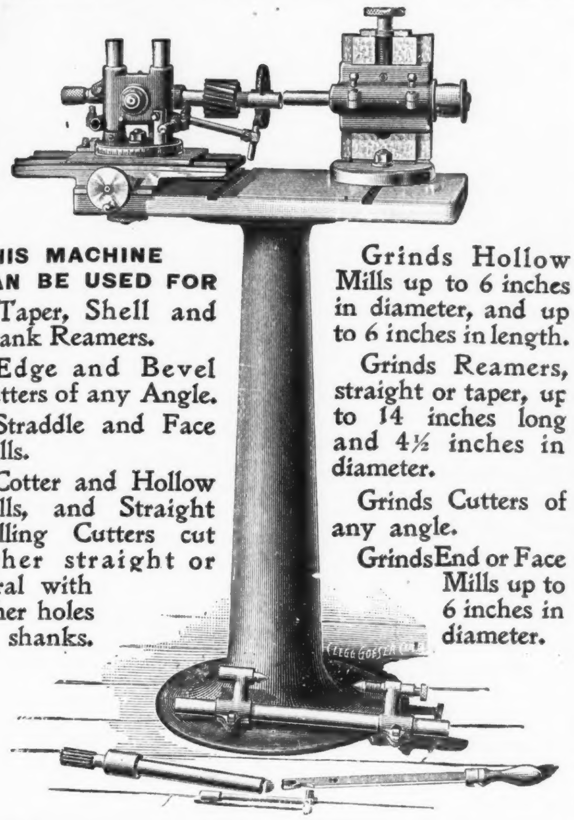

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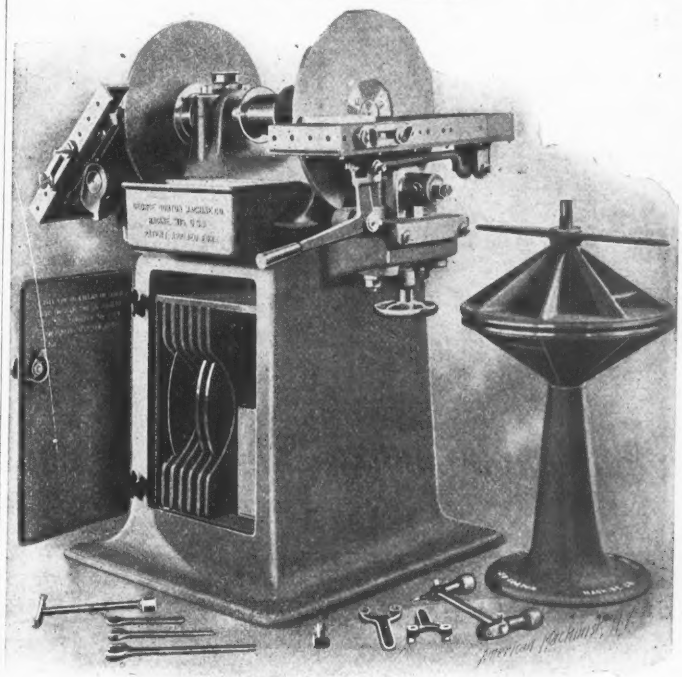

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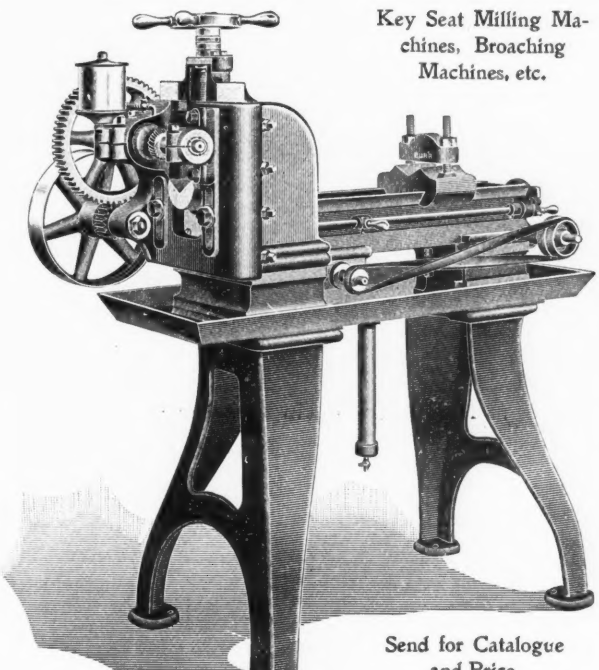

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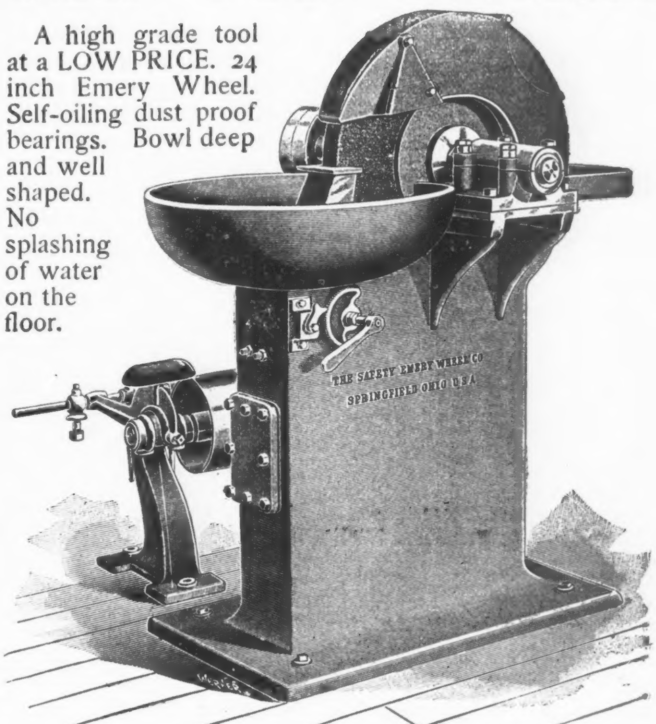

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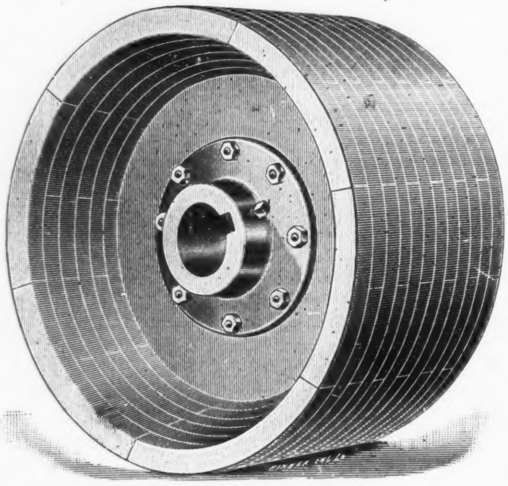

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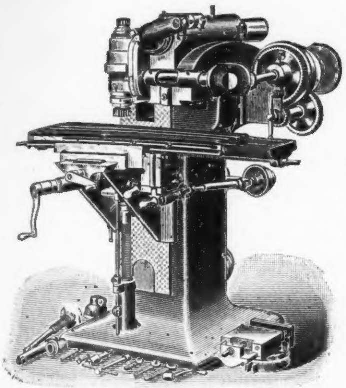

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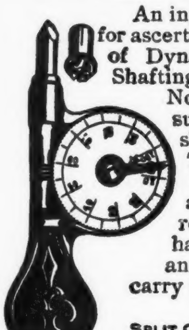

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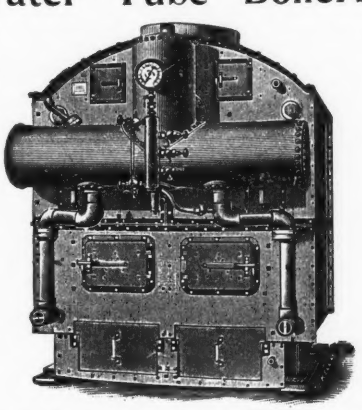

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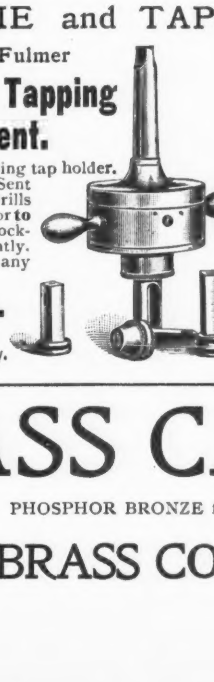

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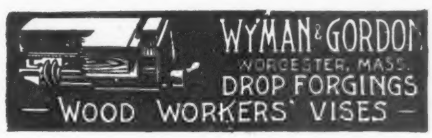

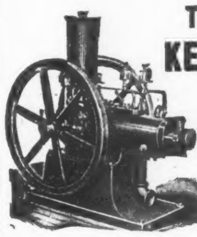

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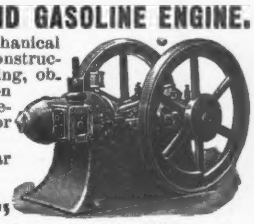

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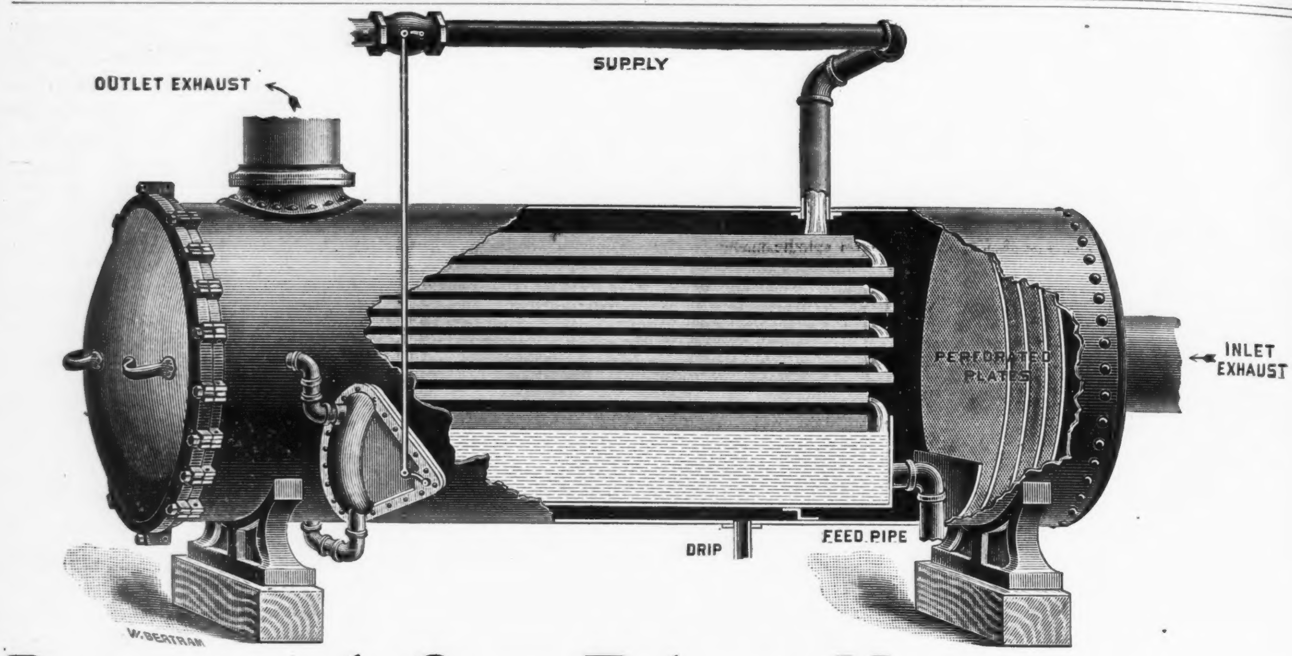

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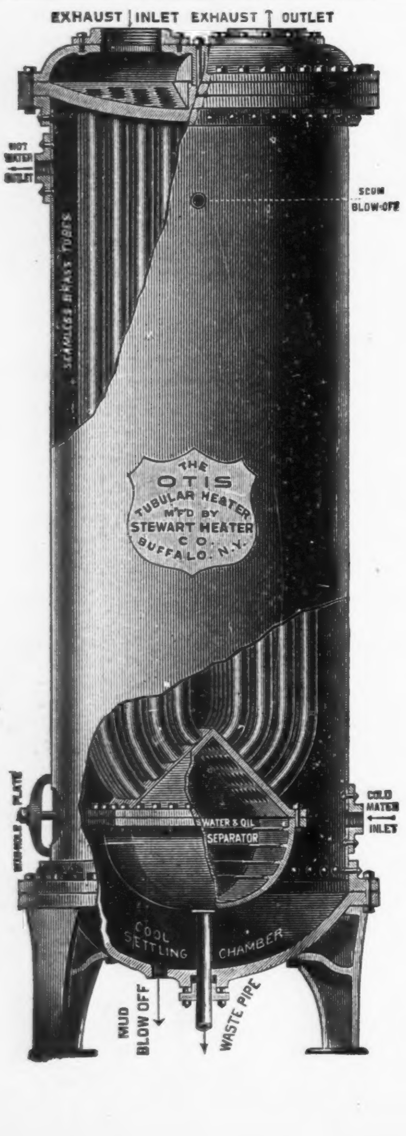

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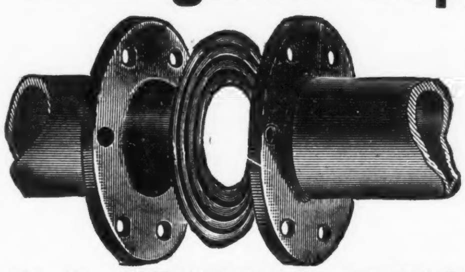

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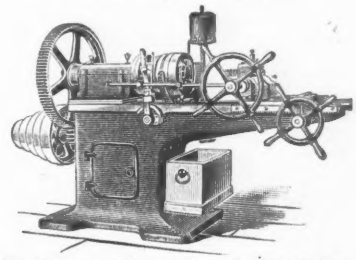

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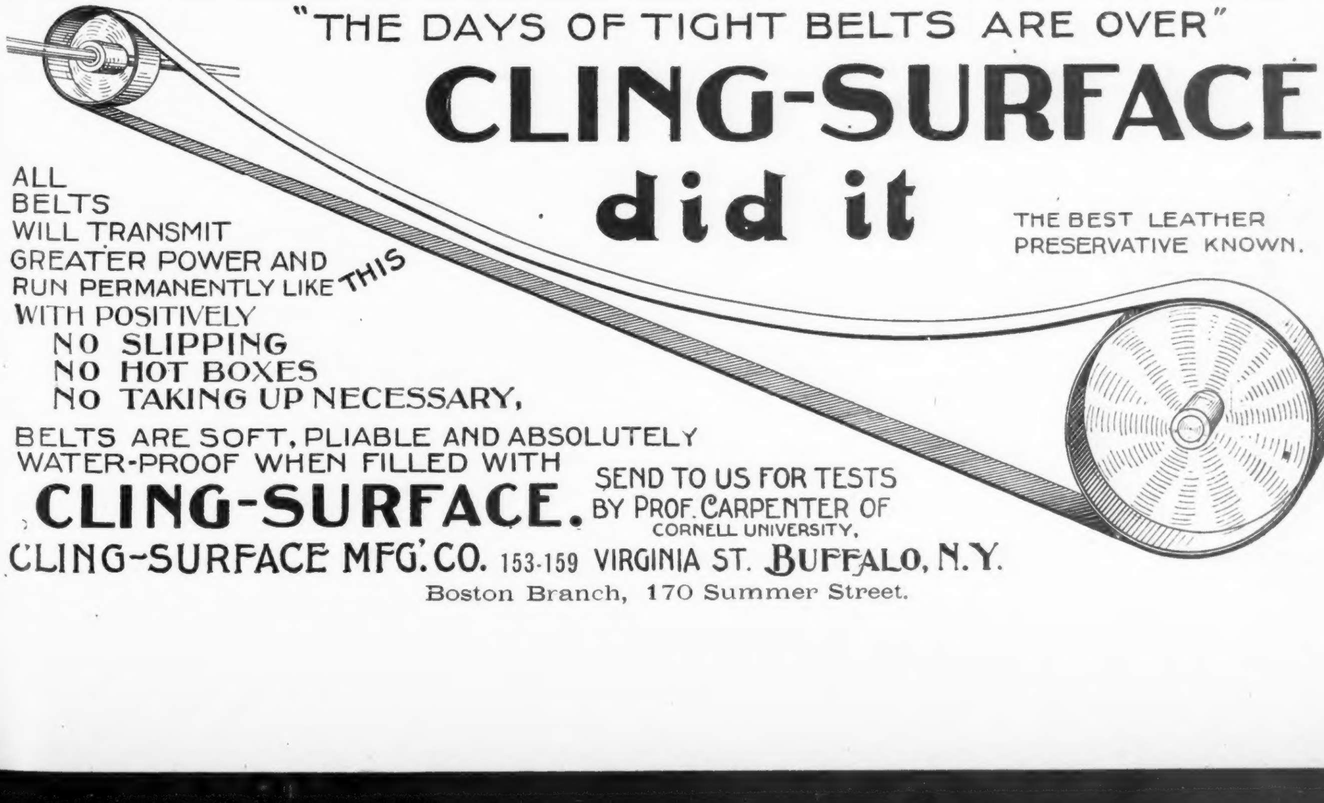

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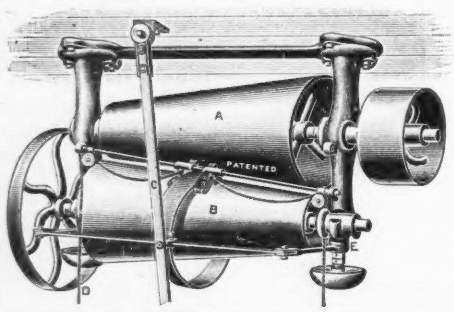

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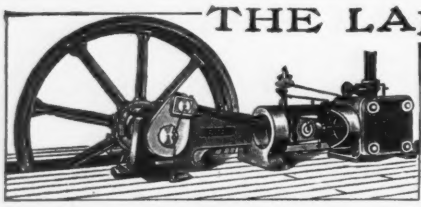

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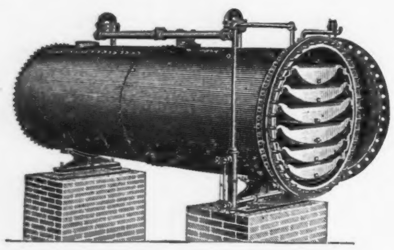

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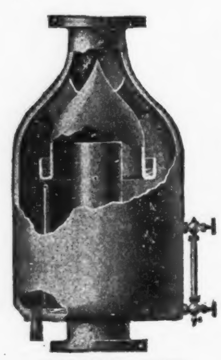

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are something more than a BUMP on the pipe. The gutters stop all entrainment without friction.

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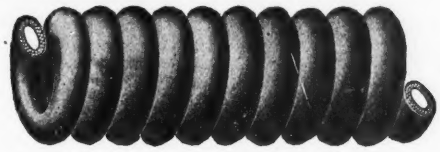

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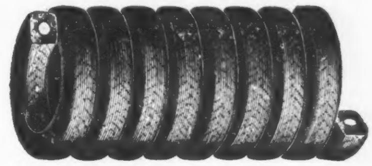

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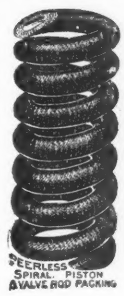

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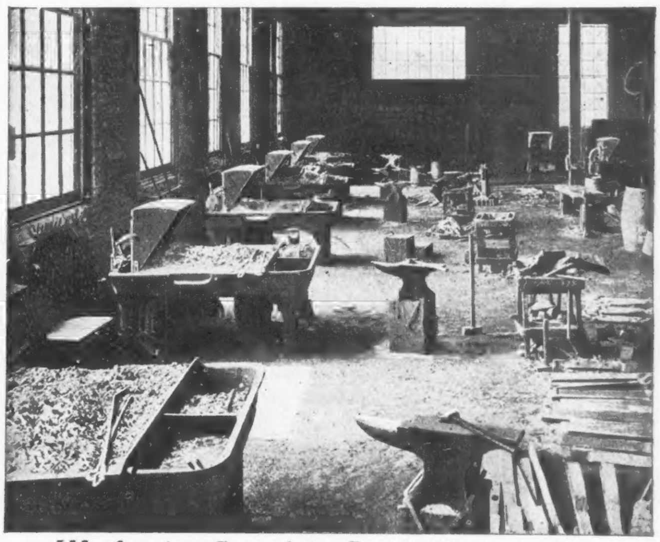

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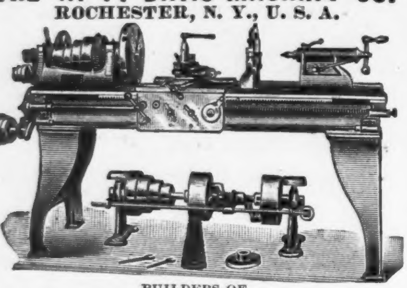

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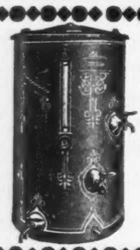

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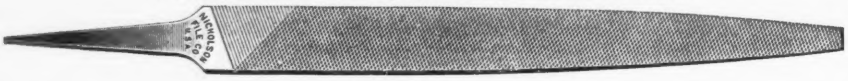

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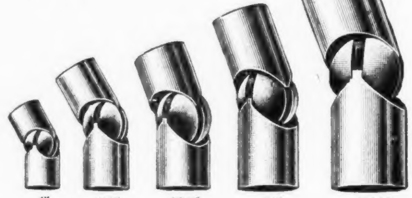

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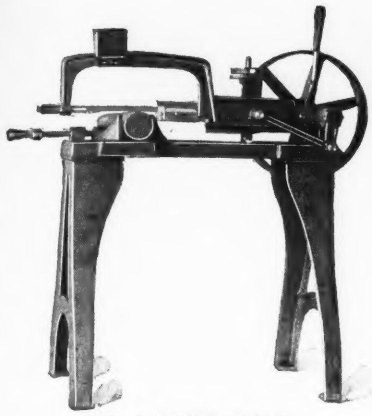

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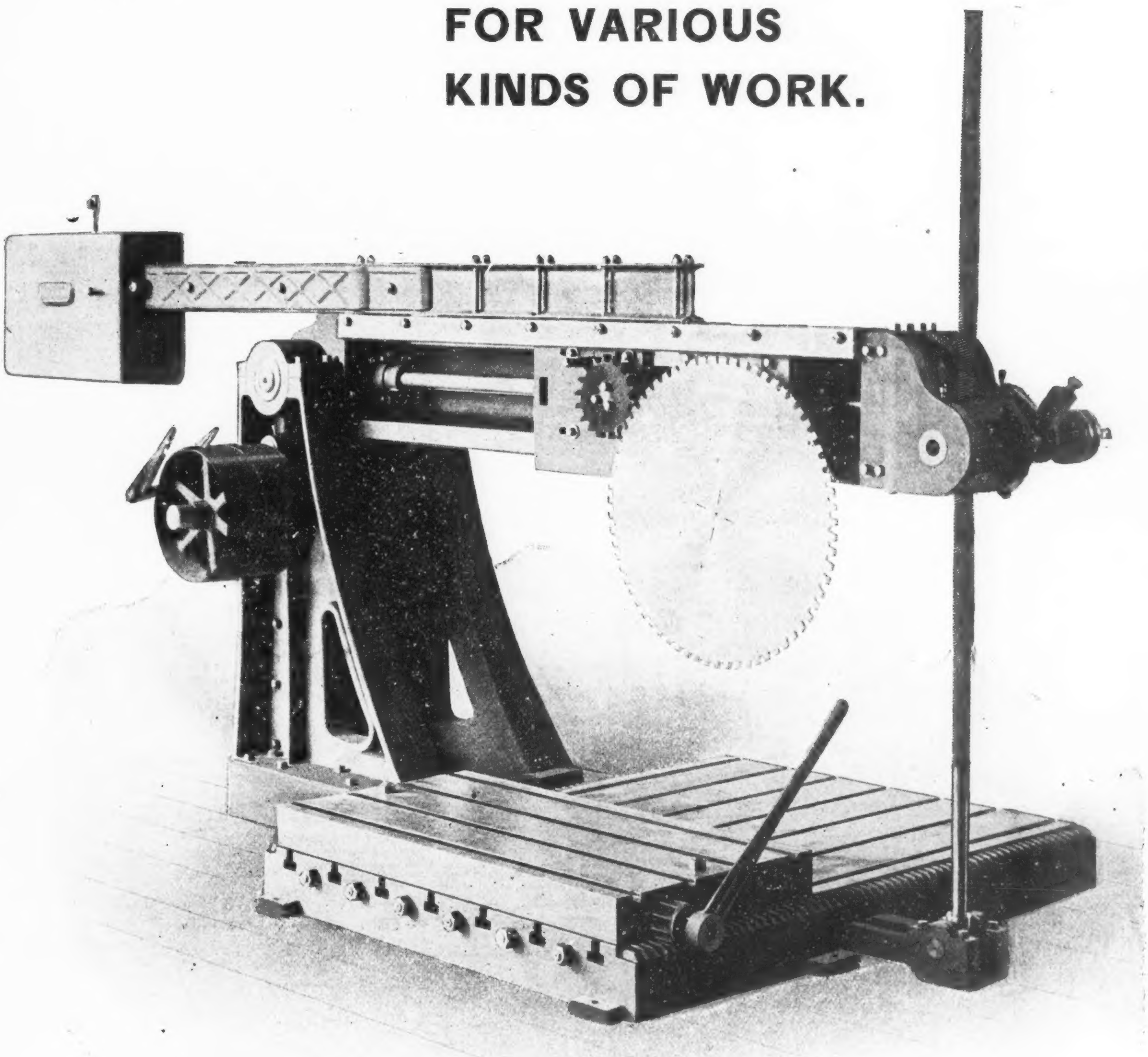

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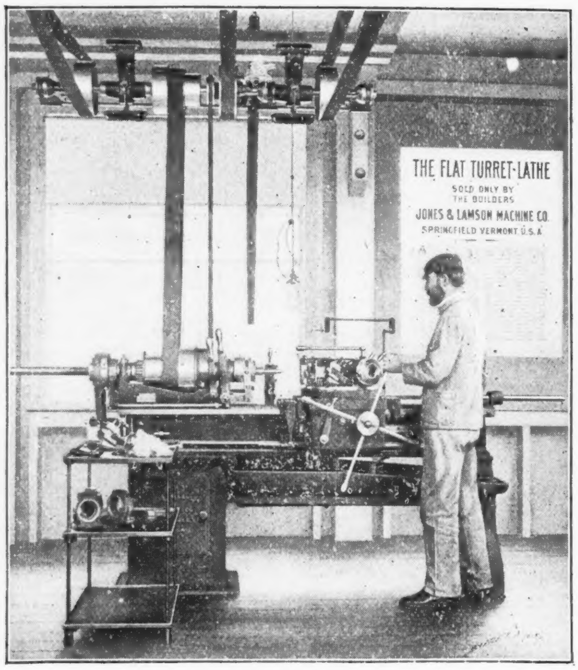

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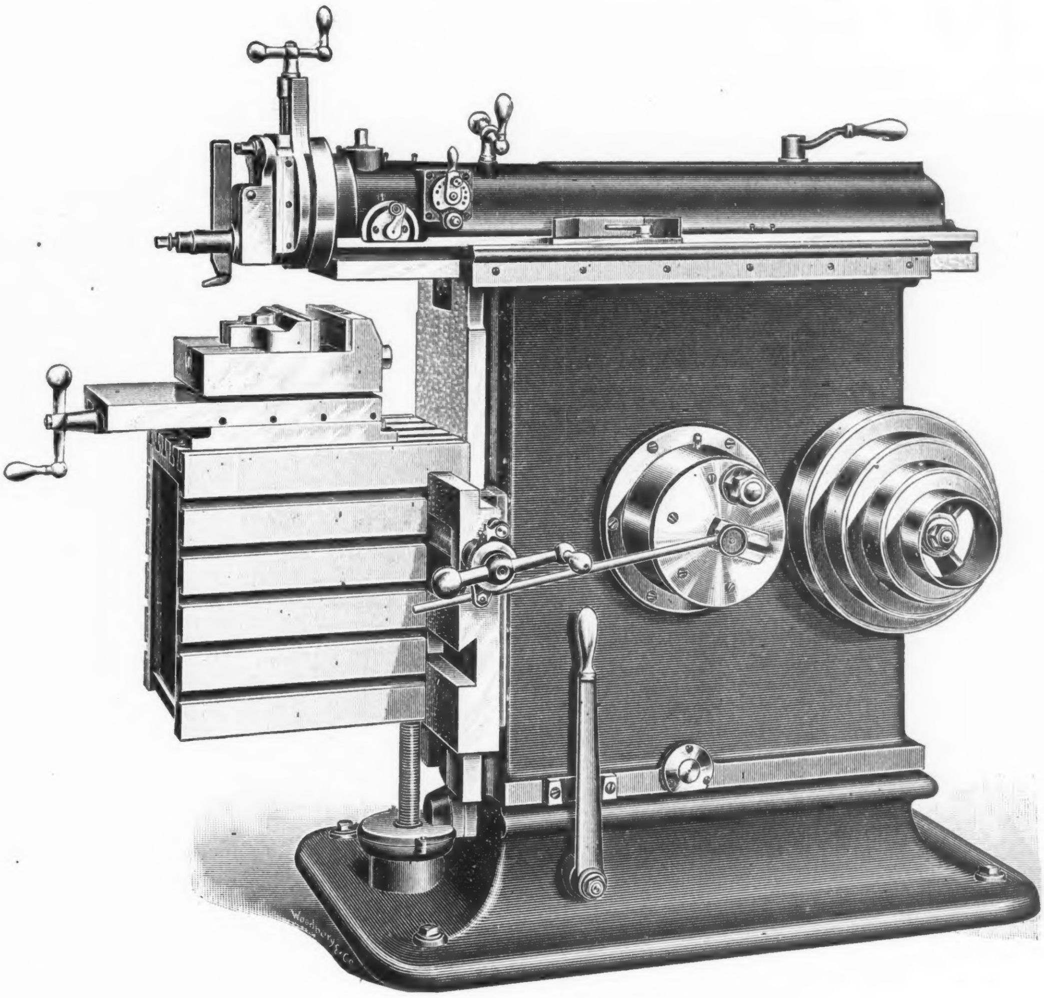

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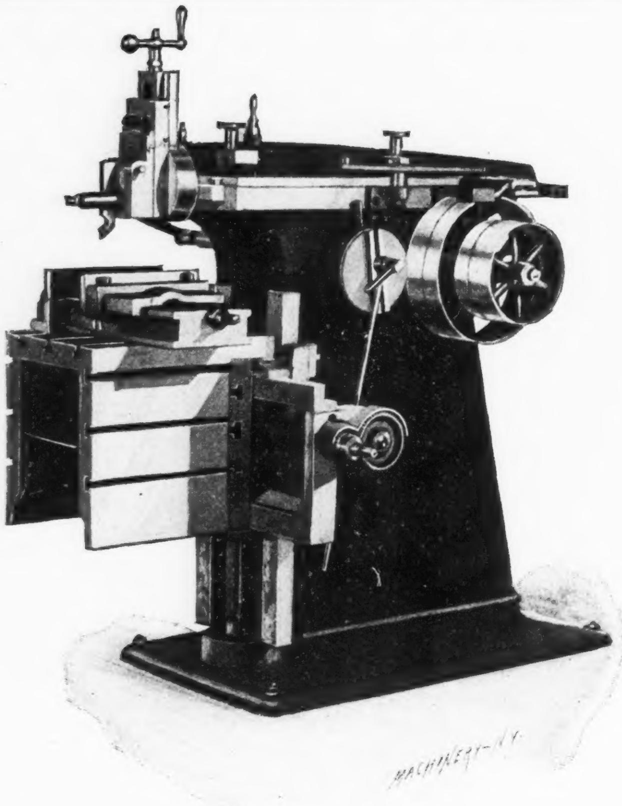
Stroke of this machine 28-inch, automatic cross traverse of 26-inches. Greatest distance between tool and top of table 18-inches. Top of table, 14 x 19 inches. Face of platen, 14 x 15 inches.



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For eighteen years we have been building

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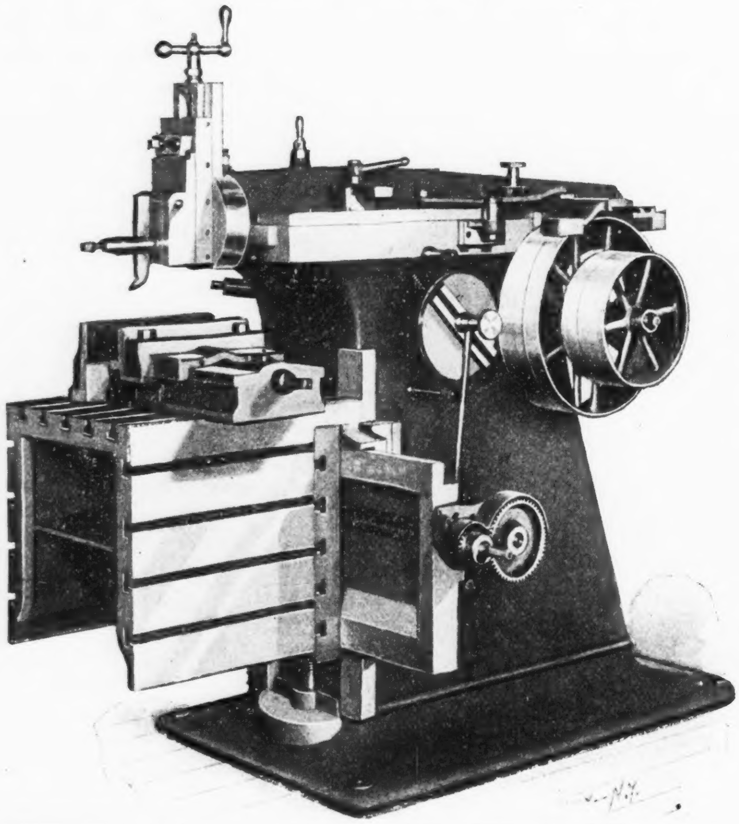
The projection of support for ram over the table. Arrangement to admit shaft through the machine for the purpose of cutting key ways.



34 INCH
GEARED
SHAPER.
Stroke of this machine 36-inch, automatic cross traverse of 34-inches. Greatest distance between tool and top of table 18-inches. Top of table, 18 x 24 inches. Face of platen, 18 x 19 inches.

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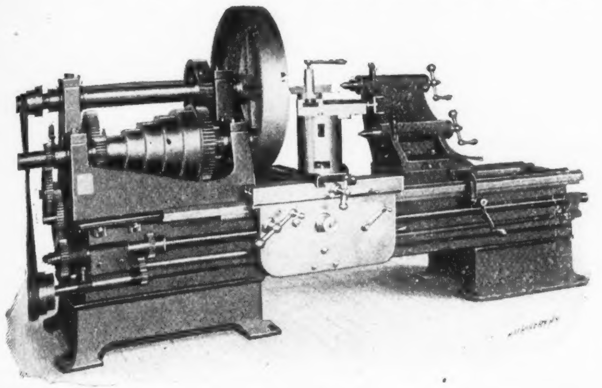

McCabe's Patent Double Spindle Lathe combines two Complete Lathes in one.

A heavy 26-in. Swing for Regular Work, and a 44-in. Swing with Internal Geared Face-Plate, Ratio 66 to 1, capable of handling the heaviest kind of work.

Wide range of Speeds and Feeds.
Wide Screw Cutting Range.
Costs but little more than an ordinary lathe.

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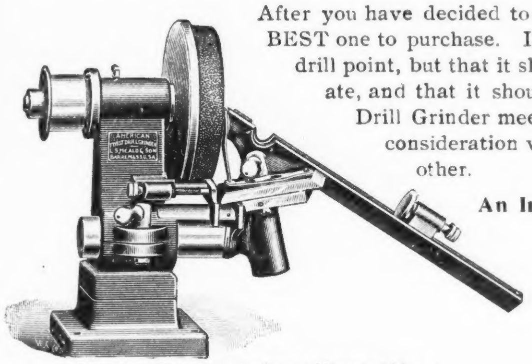

Style A. Grinds drills from ⅛ in. to 2¼ in.

After you have decided to put in a drill grinder the most important thing is to find out which is the BEST one to purchase. It is important not only that the machine should produce a correctly shaped drill point, but that it should be well and accurately made, that it should be simple and easy to operate, and that it should be so constructed as to be durable under severe usage. The American Drill Grinder meets these requirements more fully than any other machine made, and a little consideration will show that it has many features of great merit which are not found in any other.

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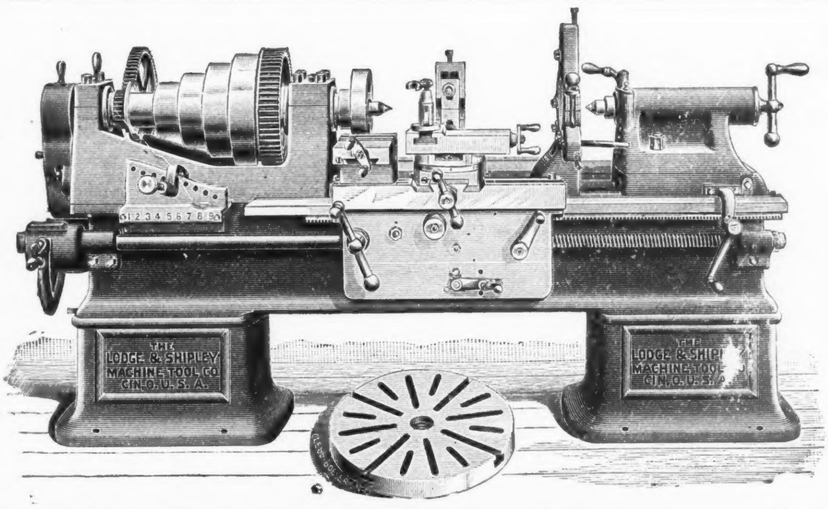

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and plenty of it each ten hours. These lathes are powerful, stiff, quickly handled and well made. Note the change gear mechanism.

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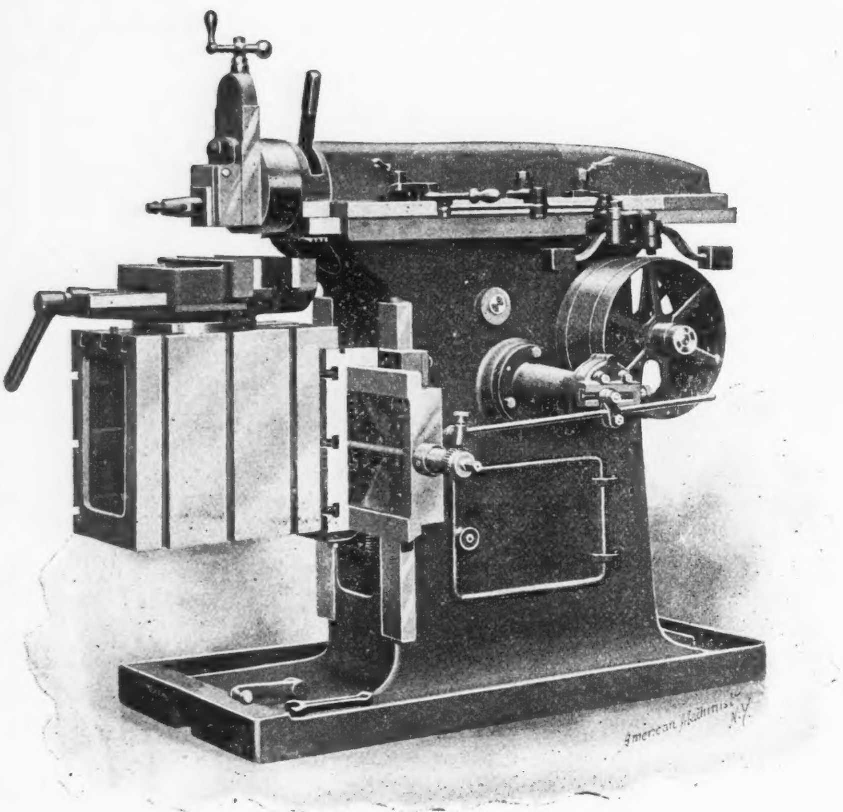

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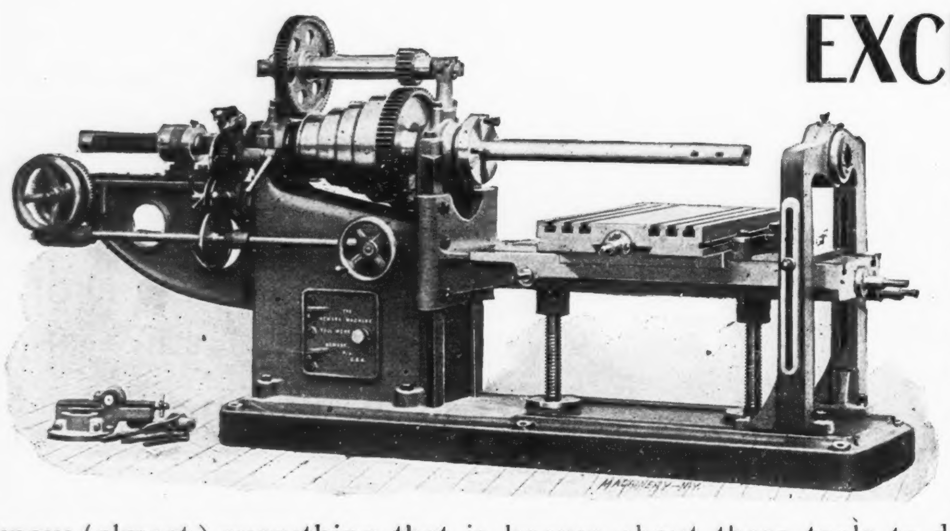

We don't have to divide our time, energy and ideas among several kinds of tools embodying radically different mechanical problems to solve. We simply eat, drink and think Horizontal Boring Machines, and the result is that we know (almost) everything that is known about these tools to-day. We have tried every device, experimented with every new theory that seemed practicable, and worked out at the expense of many years' labor, to say nothing of money, our own ideas on Horizontal Boring Machines. What we make to-day is the result. Shall we send you our illustrated catalogue?

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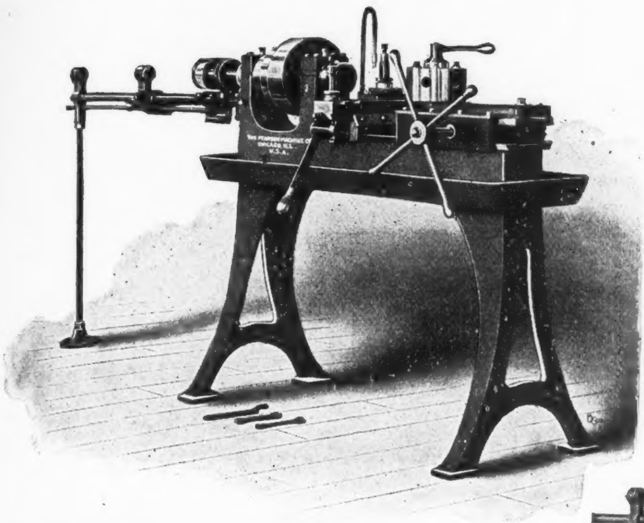

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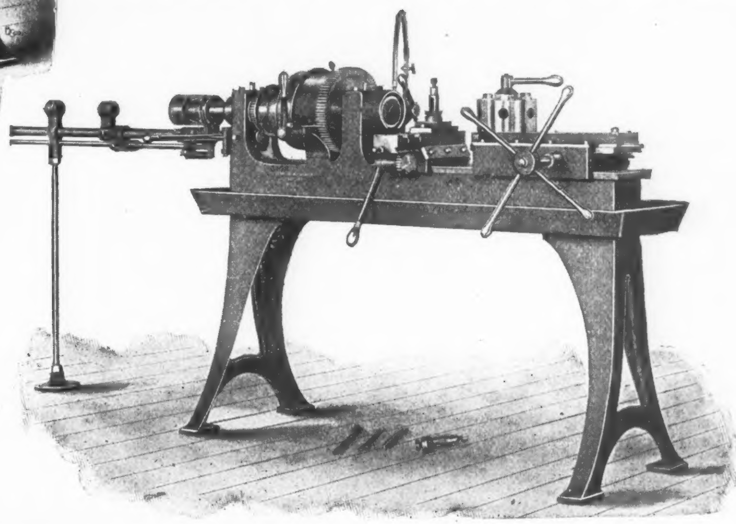

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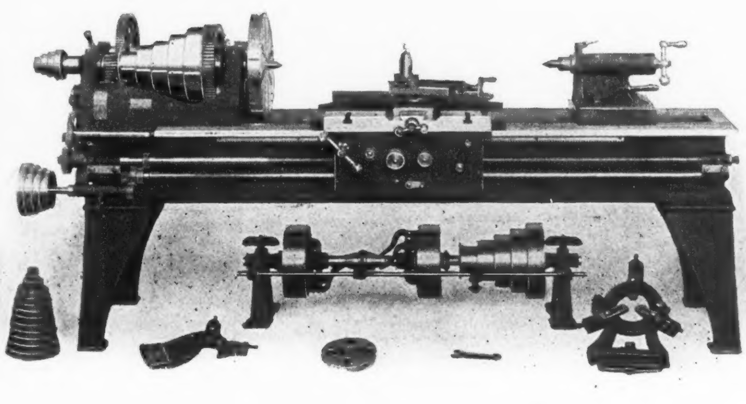

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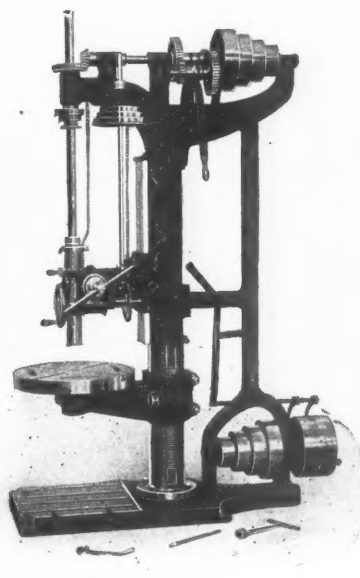

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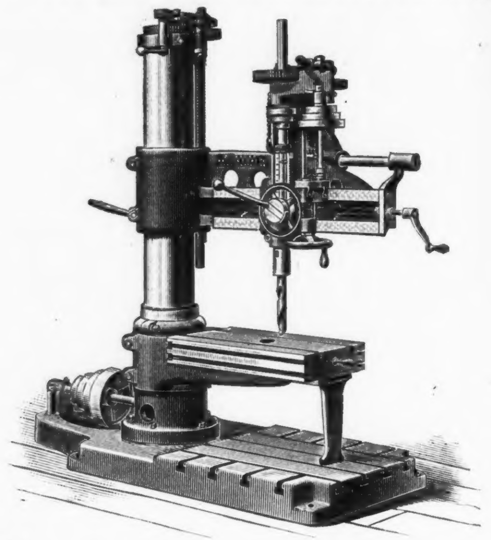

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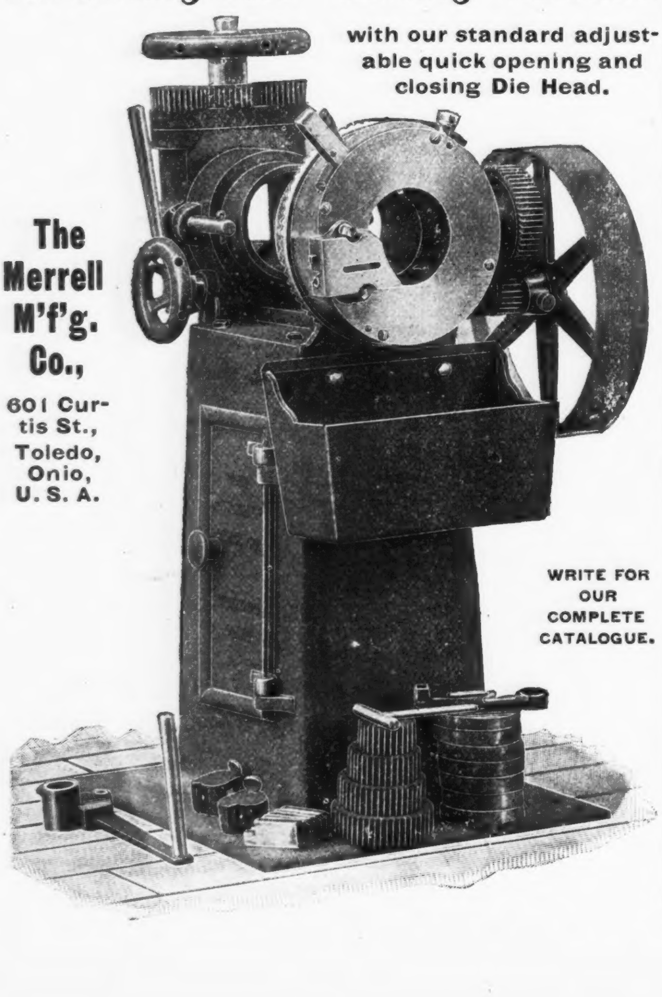

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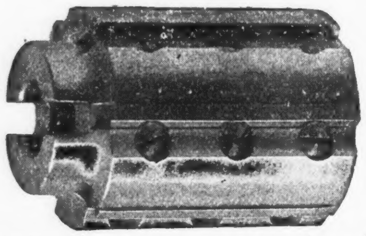

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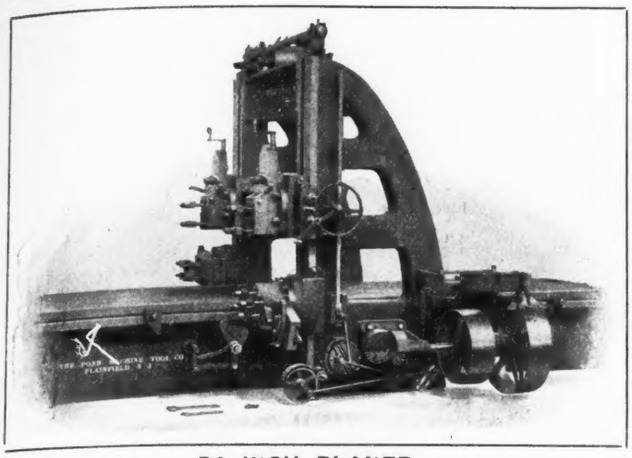

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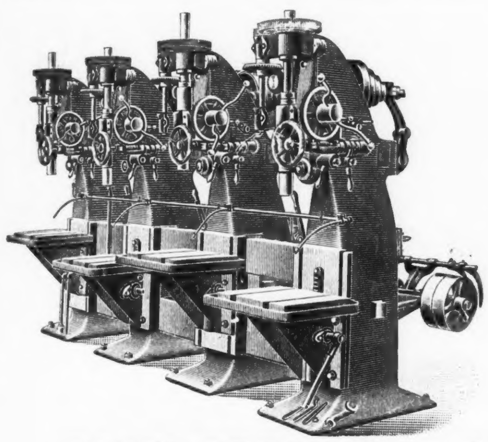

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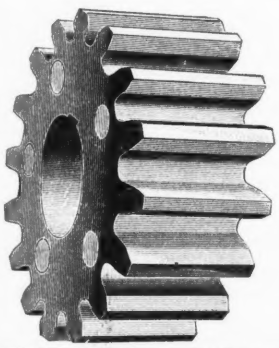

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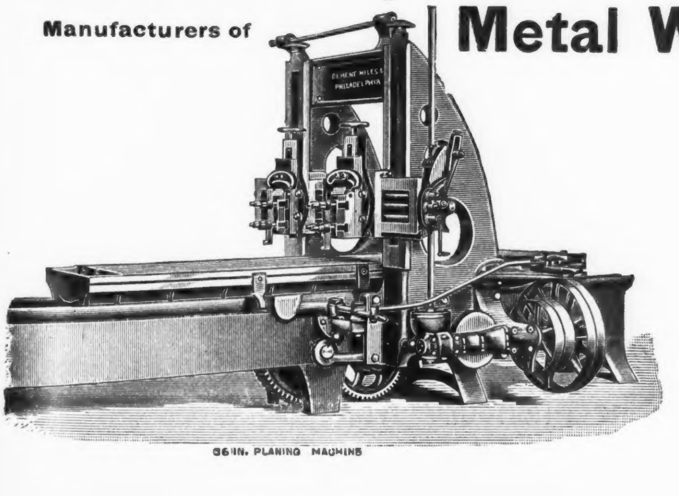

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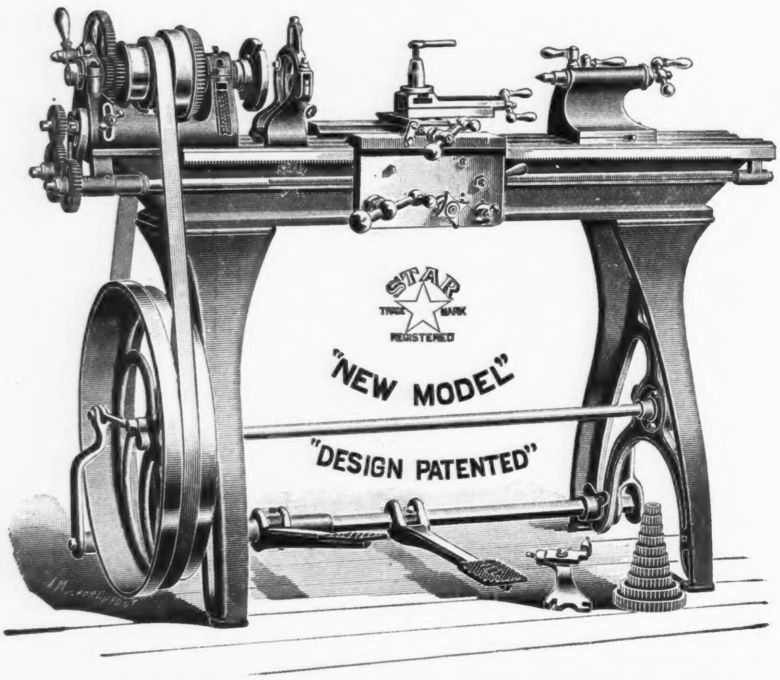

Some people think because the prices of our lathes are low, that the tools themselves are cheap. If this is your idea just look at one of them—write us for the name of a nearby user—and you will readily see that not only are the lathes thoroughly well built in every detail, but they are capable of turning out a quantity and quality of work far out of proportion to their cost.

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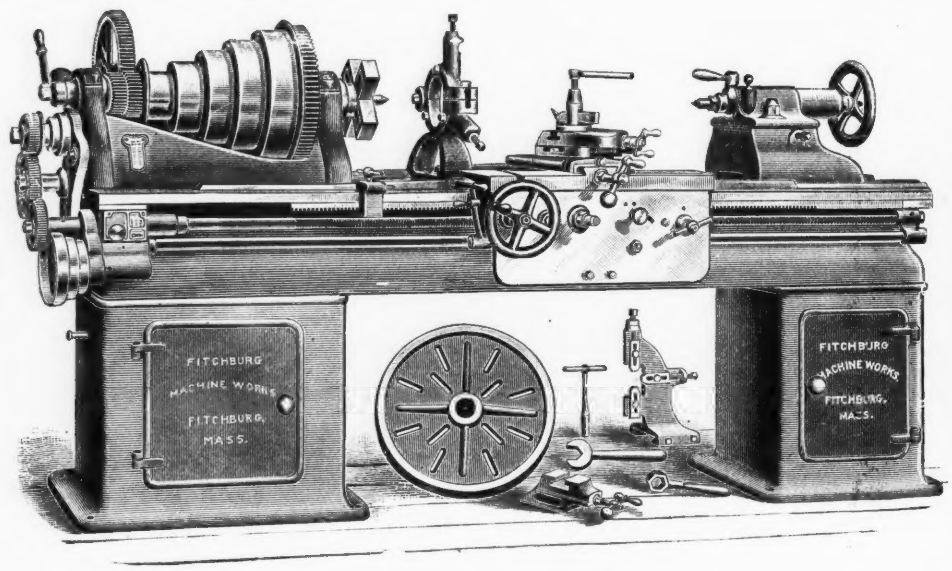
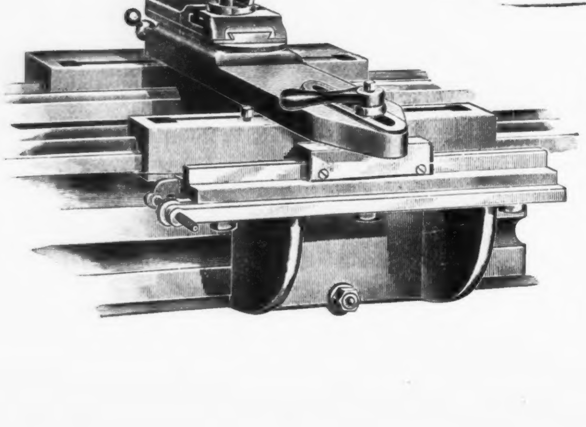
WITH CHAPMAN MICROMETER ATTACHMENT

which will set exact taper, being graduated to 1000ths and acting at right angles with the axis of the piece being turned.





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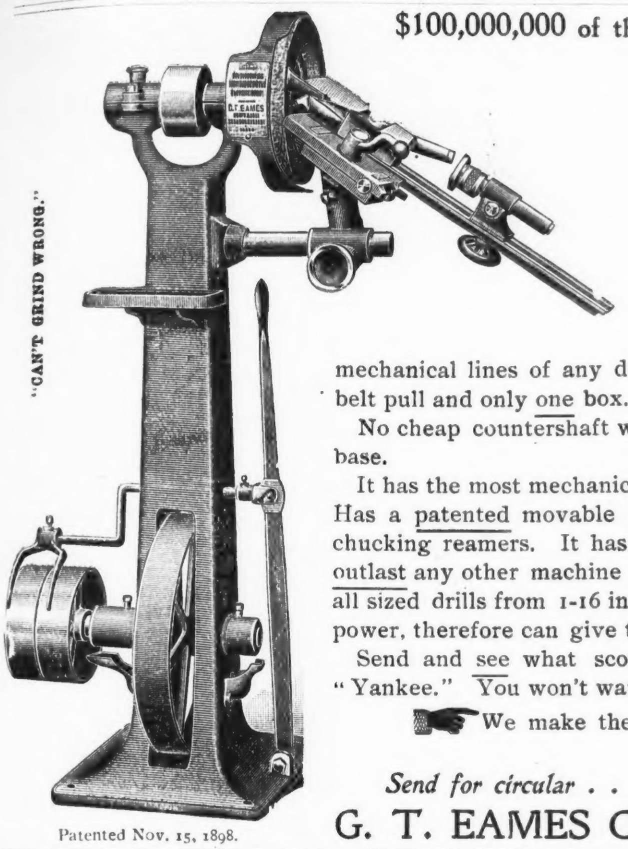

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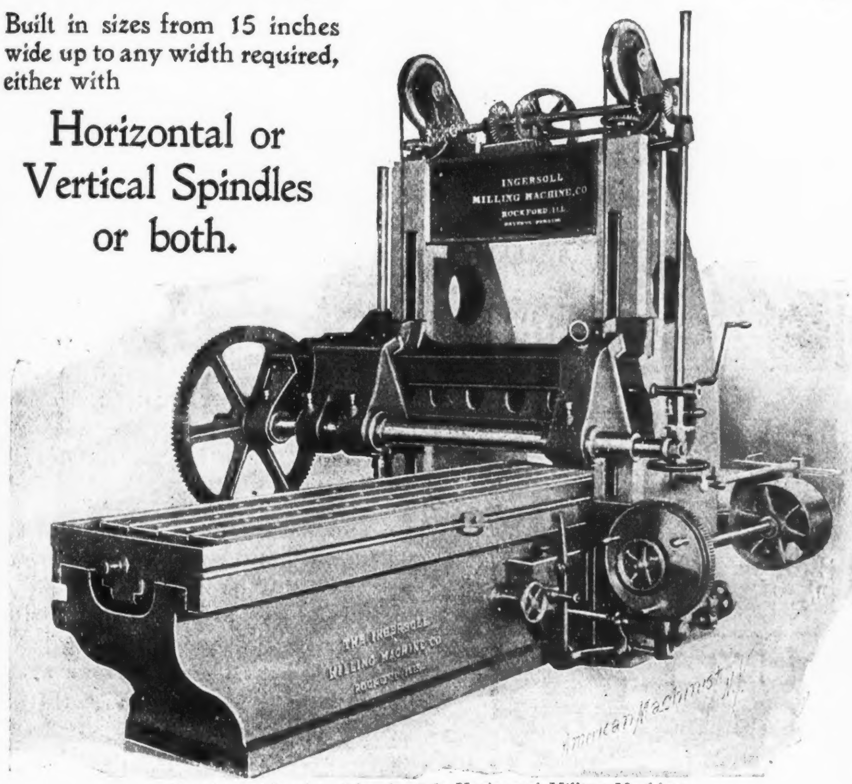

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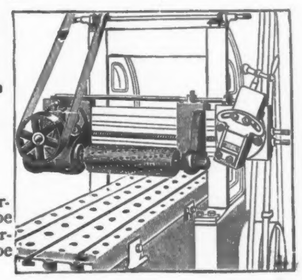

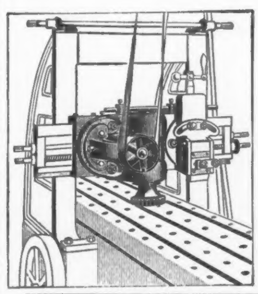

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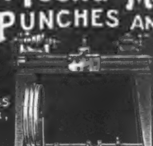

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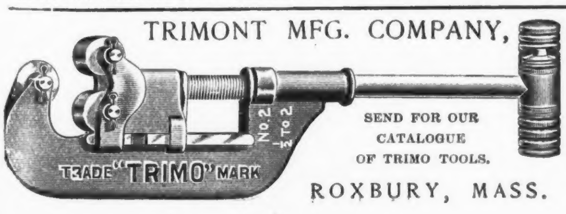

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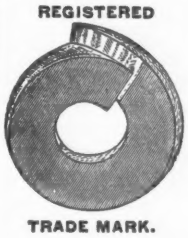

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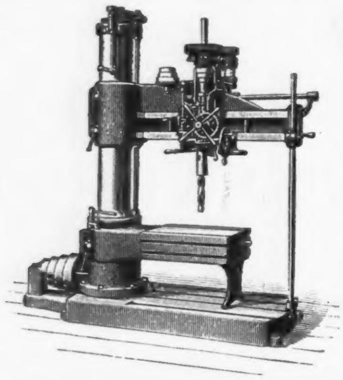

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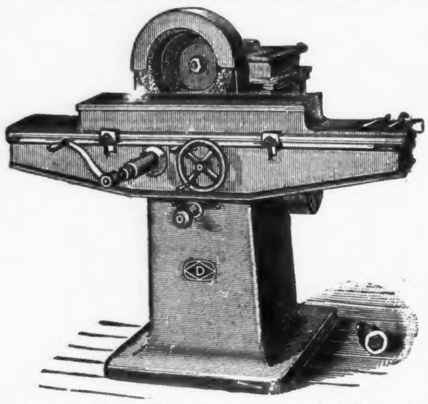

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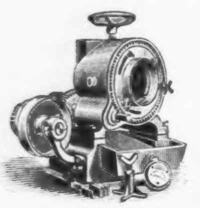

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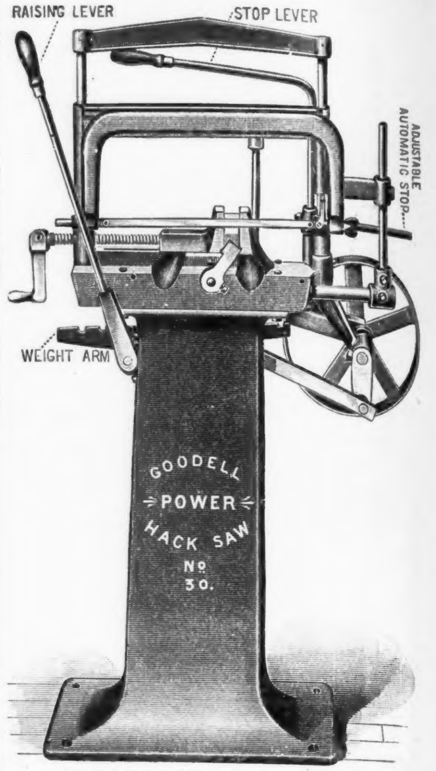

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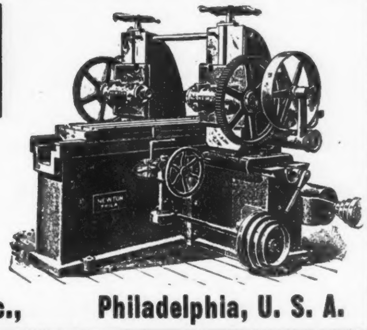

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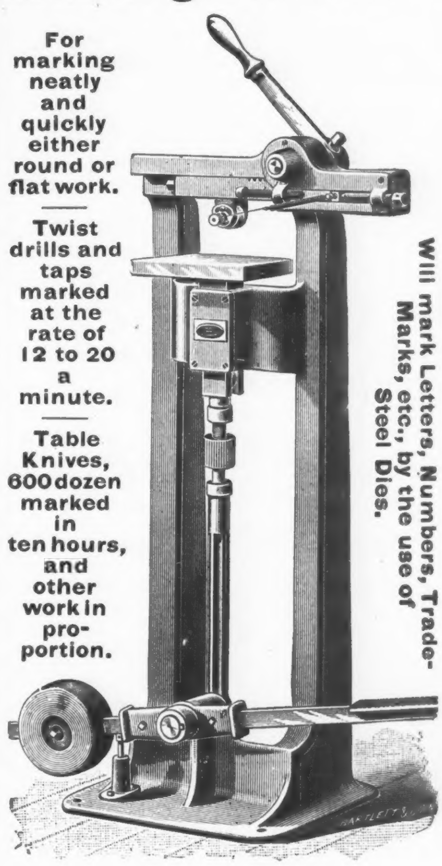

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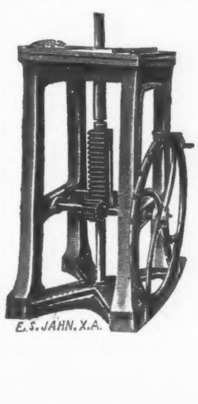

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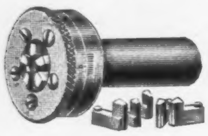

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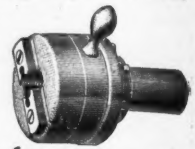

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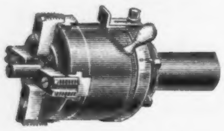

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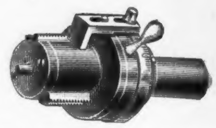

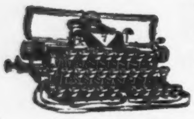

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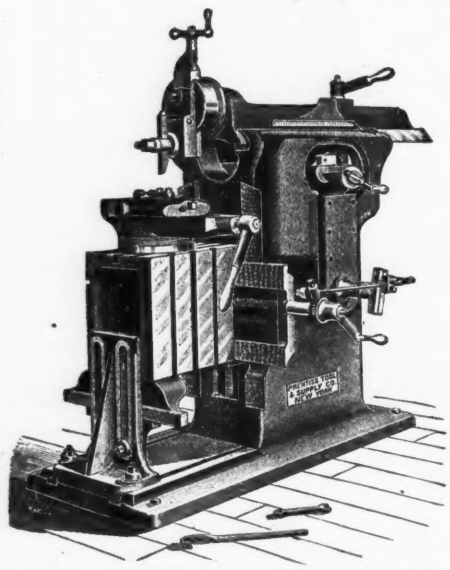

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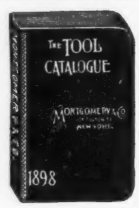

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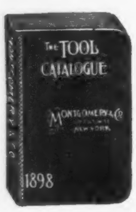

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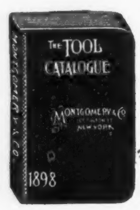

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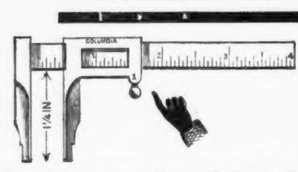

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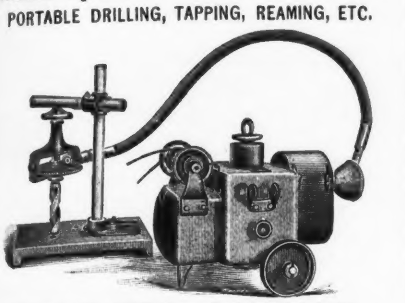

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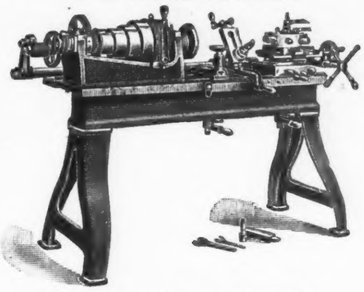

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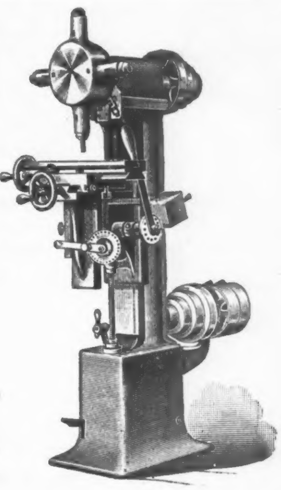

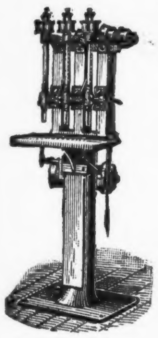

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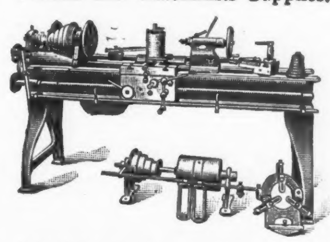
Lathes, Hand and Power Planers, Shapers, Drill Presses and Machinists' Supplies.



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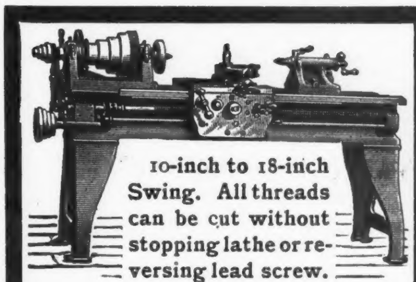

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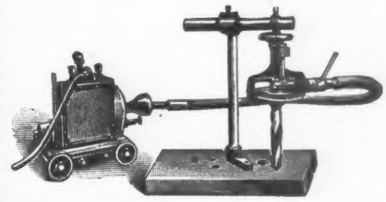

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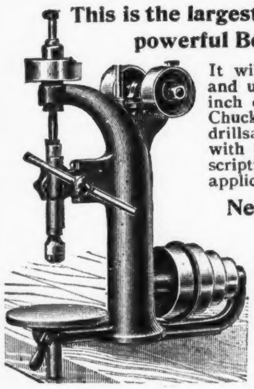

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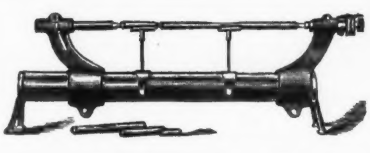

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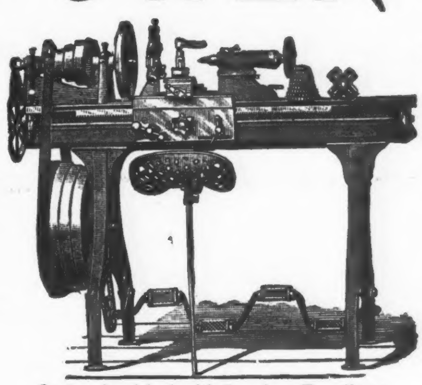

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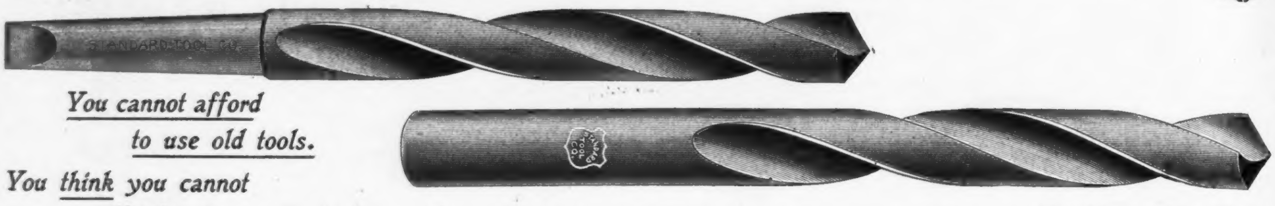

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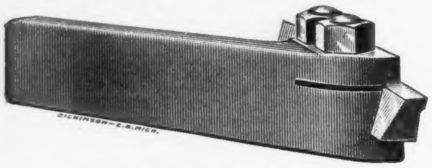

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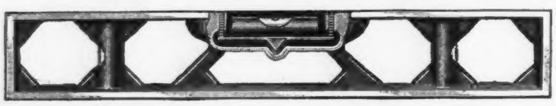

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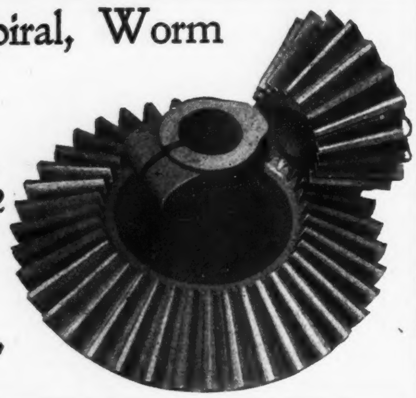

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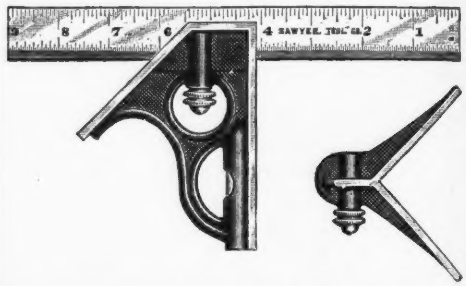

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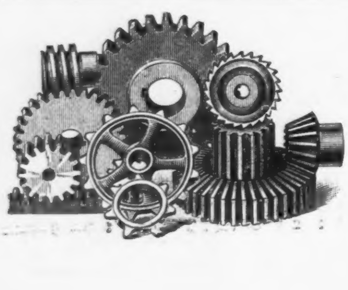

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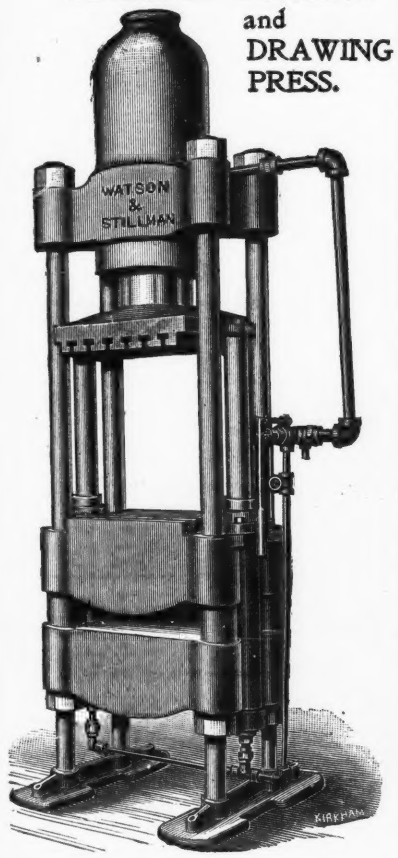

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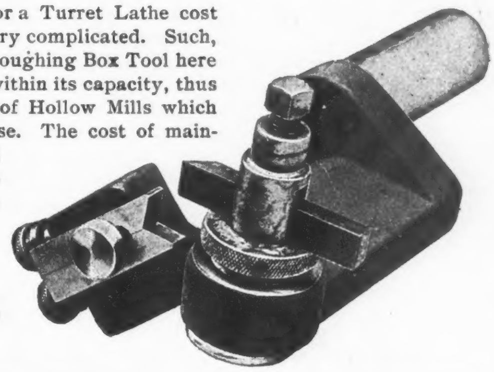

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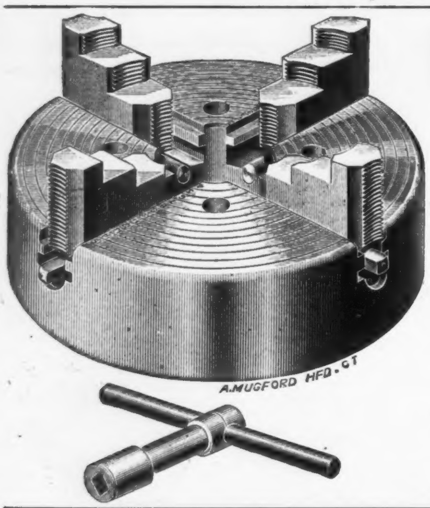

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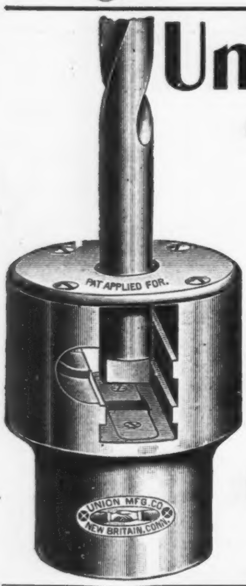

Union Drill Chucks

MADE IN SEVEN SIZES.

No. 000	holds from	0	to	¼ inch.
" 00	"	" 0	"	⅜ "
" 100	"	" 0	"	½ "
" 101	"	" 0	"	¾ "
" 102	"	" 0	"	1 "
" 103	"	" 0	"	1½ "
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Fitted with transverse slot so that Drills with tenons can be inserted, thus making it a positive Drive and accurate Friction Chuck.

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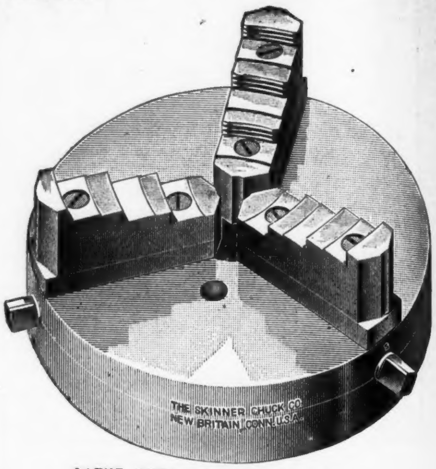

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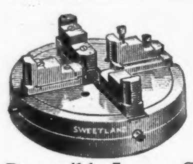

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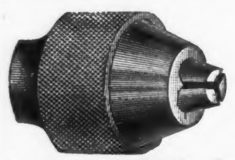

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A Necessity to the Machine Shop.

THE PRATT CHUCK is the Machinist's Ideal, and was built to supply his needs. The end of the drill is inserted in the equalizing driver, just above the jaws. This gives the drill positive rotation without the aid of the jaws, which centre and align the drill true in the chuck. THE PRATT CHUCKS ARE MADE TO STANDARD GAUGES and ARE INTERCHANGEABLE.

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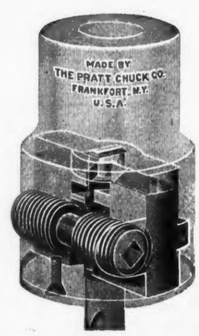

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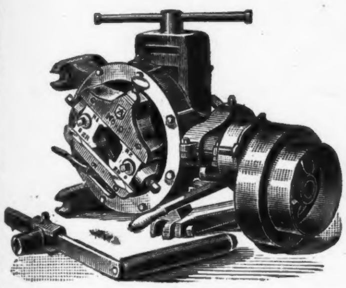

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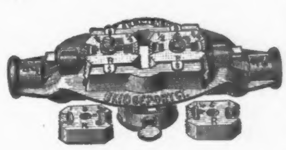

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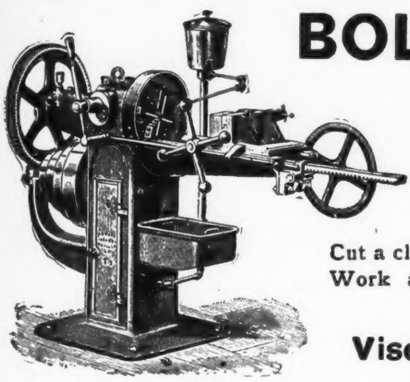

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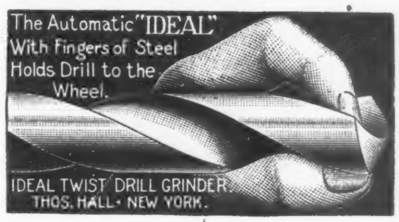

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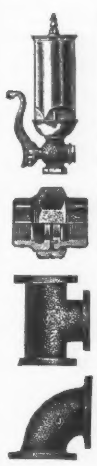

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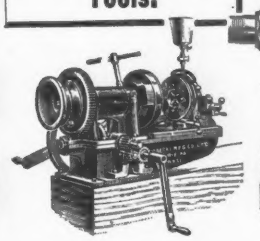

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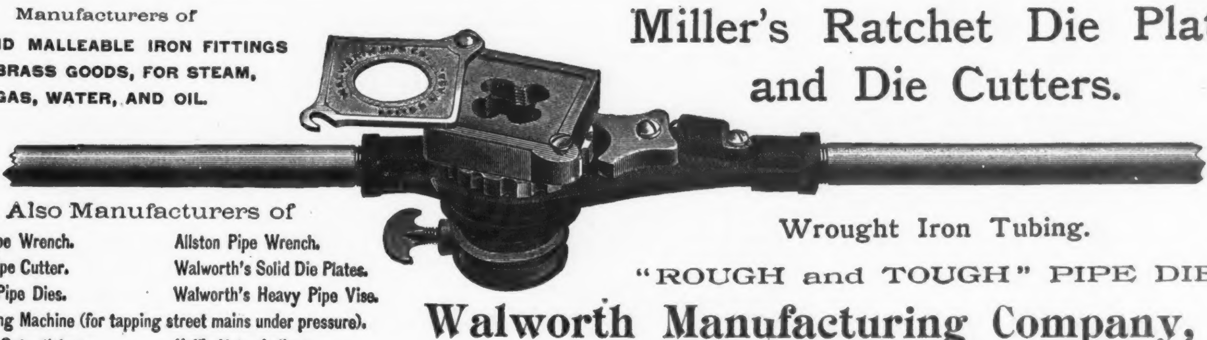

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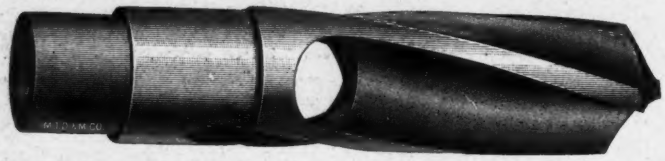

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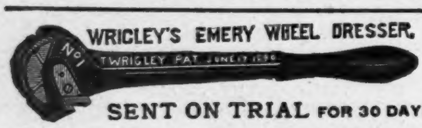

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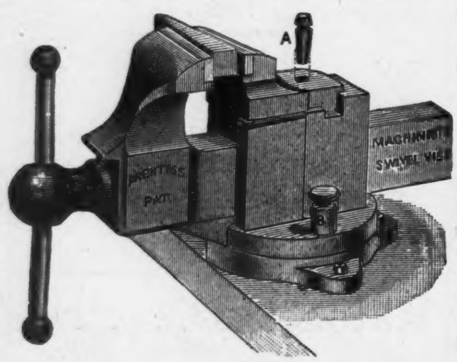

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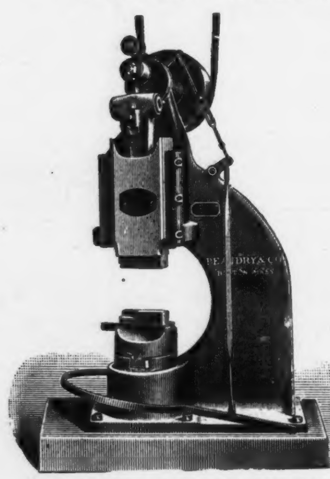

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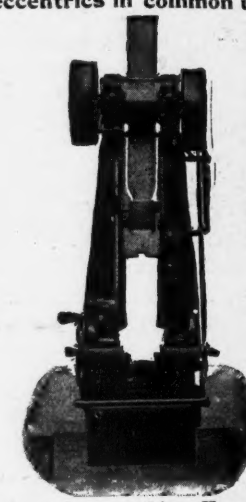

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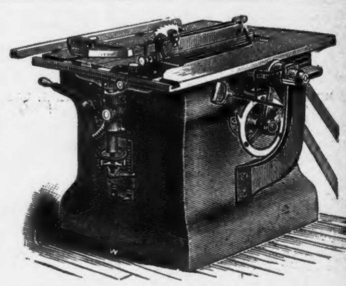

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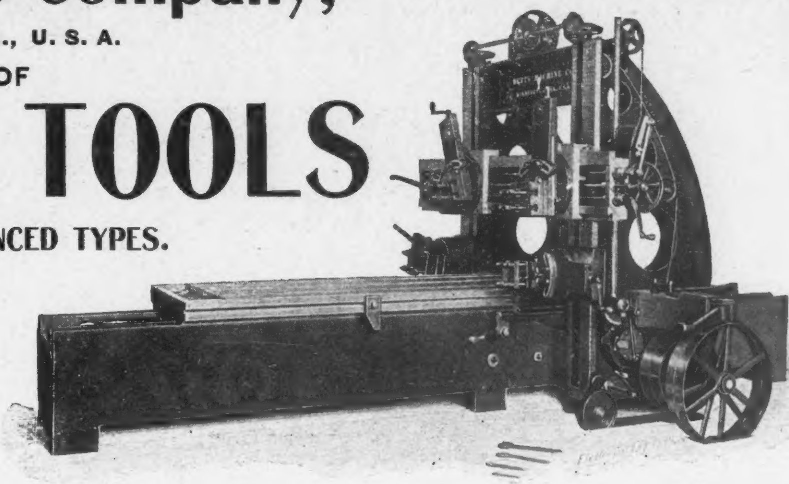

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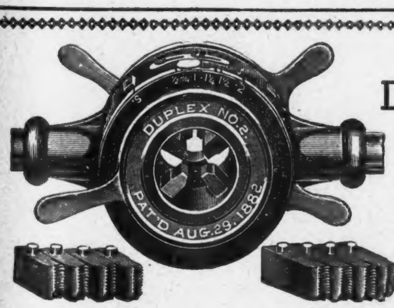

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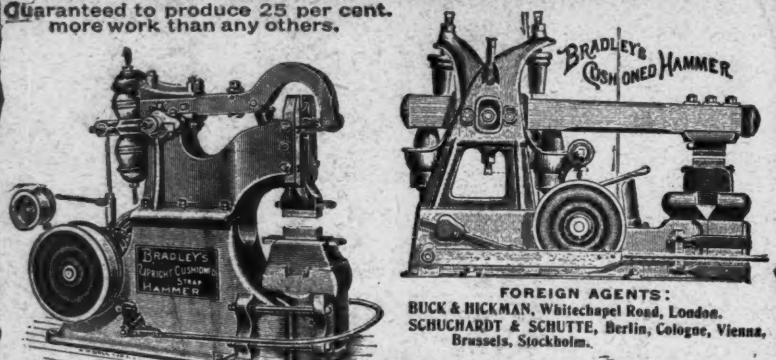

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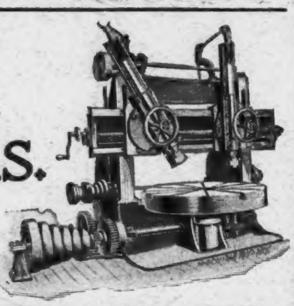

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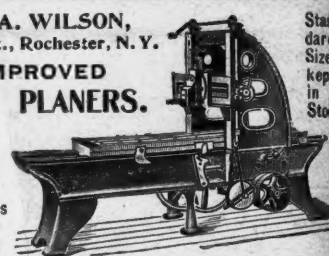

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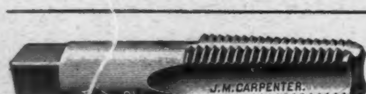

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